REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
14.Jan.03

3. REPORT TYPE AND DATES COVERED
DISSERTATION

4. TITLE AND SUBTITLE
THE EFFECT OF CASE BASED VS SUSTEMATIC PROBLEM SOLVING IN A COMPUTER MEDIATED COLLABORATIVE

5. FUNDING NUMBERS

6. AUTHOR(S)
MAJ URIBE DANIEL

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
ARIZONA STATE UNIVERSITY

8. PERFORMING ORGANIZATION REPORT NUMBER
CI02-814

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
THE DEPARTMENT OF THE AIR FORCE
AFIT/CIA, BLDG 125
2950 P STREET
WPAFB OH 45433

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT
Unlimited distribution
In Accordance With AFI 35-205/AFIT Sup 1

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

20030220 011

14. SUBJECT TERMS

15. NUMBER OF PAGES
132

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

THE EFFECT OF CASE-BASED VS. SYSTEMATIC PROBLEM SOLVING IN A COMPUTER-MEDIATED COLLABORATIVE ENVIRONMENT

by

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A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

ARIZONA STATE UNIVERSITY

December 2002

THE EFFECT OF CASE-BASED VS. SYSTEMATIC PROBLEM SOLVING IN A COMPUTER-MEDIATED COLLABORATIVE ENVIRONMENT

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ABSTRACT

The purpose of this study was to investigate the effect of instructional method (case-based approach vs. systematic approach) and collaborative group size on learners' ability to solve ill-defined problems in a web-based environment. Working in teams of two (dyads) or teams of four (quads), the participants learned how to solve problems using case-studies (case-based approach) or they learned a four step problem-solving process (systematic approach). The participants first worked through a web-based instructional program that taught them the problem-solving approach. Then, they applied the problem-solving approach to solve realistic problem scenarios. Results indicated that participants who worked in dyads performed significantly better than participants who worked in quads on one of two problem scenarios. The data did not indicate a significant difference by instructional method. Participants who worked in quads spent significantly more time on the learning program than participants working in dyads. Analysis of time spent solving problems revealed that participants who used the systematic approach spent more time solving the problems than did participants in the case-based approach. All treatment groups had positive attitudes toward working with others, the instructional materials, and applicability of problem-solving skills to other settings. However, working collaboratively using a computer-mediated medium was the lowest rated item in the attitude survey, indicating participants did not enjoy collaborating using a computer. Analysis of the communications between team members indicated that 95% of the communications that took place were related to the problem-solving task. Implications for the implementation of computer-mediated collaboration in distance learning are discussed.

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Introduction

Problem solving is regarded as one of the most important cognitive activities in everyday life and a primary goal of the education process (Jonassen, 2000; Phye, 2001). How to design effective instructional programs that help learners acquire the skills to solve ill-defined problems has become a focus of the instructional technology field in recent years. According to Jonassen (2000), ill-defined problems are characterized by a lack of knowledge of all elements of the problem, multiple solutions or solution paths, multiple criteria for evaluating solutions and a need for the learner to make judgments and express personal opinions or beliefs.

Some critics argue that current instructional design models are not well suited to teach the skills necessary to solve ill-defined problems (Van Merrienboer, Clark, Moore & de Crook, 2002). To fill this apparent gap, several problem-solving instructional strategies based on current cognitive and learning theories have been advanced. These strategies emphasize solving realistic problems in authentic contexts (Oliver & Harrington, 2000; Bastiaens & Martens, 2000).

The following paragraphs present a review of the literature on case-based learning and the systematic approach to problem solving. Also, the relationship between collaborative learning and problem solving is explored and a review of the research on the effect of group size on performance is provided.

Case-Based Approach to Problem Solving

Proponents of case-based learning describe it as a powerful instructional approach that is engaging and that leads to sustained and transferable learning of problem-solving skills (Mergendoller, Bellisimo, & Maxwell, 2000; Stepien & Gallagher, 1993). Case-based learning uses authentic, complex problems as the impetus for learning and fosters the acquisition of both disciplinary knowledge and problem-solving skills (Bligh, 1995; Edens, 2000; Flynn & Klein, 2001; Levin, 1995). Because of its potential to enhance knowledge acquisition, case-based learning has become a popular method to deliver classroom instruction in education, and it has been used in a variety of academic environments (Edens, 2000; Flynn & Klein 2001, Kinzie, Hrabe & Larsen, 1998, Shulman, 1992). Julian, Kinzie and Larsen (2000) propose that case-based learning is more effective than didactic teaching methods because it more accurately represents the complexity and ambiguity of real-life problems and it provides a means for allowing learners to develop the kind of problem-solving strategies that practicing professionals use.

Van Merrienboer et al. (2002) identify case-based learning in the 4 Components/Instructional Design (4C/ID) model as a scaffolding technique that supports the learner at the beginning of complex tasks. According to Van Merrienboer et al., case studies are product-oriented support for complex learning that provide the learner with a given state, a desired goal state, and the solution to the problem. They theorize that this scaffolding will help the learner develop mental models from the given examples that will aid in the solution of the same type of complex problems.

Systematic Approach to Problem Solving

Another technique that can be used to solve complex tasks is that of a systematic approach to problem solving. Van Merrienboer et al. (2002) describes the systematic approach as a strategy that uses heuristics and/or rules-of-thumb, which can be applied to solve a complex task. Gagné (1985) describes problem solving as an extension of both rule learning and schema learning. He argues that problem solving is not just the application of rules to achieve a goal or solve a problem, but it is also a process that yields new learning. When a learner is faced with a problem situation, Gagné (1985) argues, the learner will recall previously learned rules in an attempt to find a solution. In applying the rules and finding a solution, the learner will also develop a "higher-order rule" that can be applied to problems in the same domain or of similar characteristics. Along the same lines, Van Merrienboer (in press) describes the systematic approach as a process-oriented learner support for complex learning that provides the learner with a cognitive strategy that can be applied when the learner is confronted with problem-solving tasks in the same domain.

A systematic approach to solving problems has been found to be effective in a variety of academic disciplines. For example, a systematic approach that combines elements of clinical reasoning and the scientific approach is taught early to medical students and is refined as the student gains experience (Benjamin & Hamdy, 1993). In a study of high-school mathematics students in the Netherlands that compared different approaches to problem solving, the results revealed that students that learned mathematics through a heuristic or systematic approach were able to use their

mathematical knowledge to solve problems better than students who used a discovery approach. (Van Streun, 2000).

Collaborative Learning and Problem Solving

The mental models and cognitive strategies developed by the learner to solve complex tasks can be enhanced through the use of a collaborative environment. Some current research suggests that a collaborative learning environment can positively affect performance on problem solving tasks (Flynn & Klein, 2001; Johnson, Johnson, & Smith, 1991; Mergendoller et al., 1999). Collaborative learning is defined as "an activity that is undertaken by equal partners who work jointly on the same problem rather than on different components of the problem" (Brandon & Hollingshead, 1999). Smith and McGregor (1992) also defined collaborative learning as a “joint intellectual effort.”

Although collaborative learning is often used synonymously with cooperative learning, there are some important differences between the two learning strategies. According to Johnson and Johnson (1988) the five elements necessary for a successful cooperative environment are positive interdependence, face-to-face promotive interaction, interpersonal and group skills, group processing, and individual accountability. In contrast to cooperative learning, collaborative learning is less structured and requires students to work more closely together on a task. Damon and Phelps (1989) state that the two elements essential for collaboration and which distinguish it from cooperation are equality, or students of similar abilities working together, and mutuality or learners working on the same problem rather than different components of the problem. A meta-analysis of the use of collaborative learning in

higher education courses indicated that collaborative learning promotes higher achievement, higher-level reasoning, more frequent generation of ideas and solutions, and greater transfer of learning than individual or competitive learning strategies (Johnson et al., 1991). Other researchers suggest that collaborative learning is more effective than cooperative learning in areas requiring higher order thinking skills such as problem solving (Damon & Phelps, 1989; Doran, 1994).

The research conducted to examine the effect of collaboration on problem solving supports the hypothesis that a collaborative learning environment is well suited for solving problems (Spector & Davidsen, 2000). In several studies conducted to analyze the impact of a collaborative environment on problem solving, collaboration was found to improve performance on complex or higher-order thinking activities (Chang & Smith, 1991; Johnson & Chungh, 1999; Mergendoller et al., 1999). In these studies, learners appeared to benefit from the opportunity to discuss the problem, brainstorm potential solutions and arrive at a final solution. However, these studies have been conducted in face-to-face environments. Additional empirical research is necessary to indicate whether the positive effects of collaborative learning during problem solving tasks will also be obtained in a computer-mediated collaborative environment. With enrollments in courses delivered over the Internet in the United States already at well over 100,000 students (Simonson, Smaldino, Albright & Zvacek, 2000), it is important to confirm that the positive effects of collaborative learning in a face-to-face environment are also evident in a computer-mediated collaborative learning structure.

Computer-Mediated Collaborative Learning

A web-based distance education environment may be well suited for the teaching and learning of complex skills such as problem solving. In the web-based environment, a realistic setting can be created where the learner has access to a vast amount of authentic information and can work collaboratively through real-time computer-mediated communications to solve ill-defined problems. These characteristics of the web and a computer-mediated environment may tend to facilitate problem-based learning. According to Laffey, Tuper and Wedman (1998), computer-mediated learning on the World Wide Web is suitable for problem-based learning because it provides ample resources, allowing students to do their own planning and present new forms of knowledge, which expand the mechanisms for collaboration and communication. Others also argue that computer-mediated collaboration and the web are excellent technologies for case studies and integrating higher-order learning (Jonassen, Prevish, Christy & Stavrulaki, 1999). Miller and Miller (2000) also suggest that the characteristics of the Internet environment, which provides a hyperlink structure with easy access to relevant information, realistic and enhanced media and synchronous communication capabilities, make it an effective learning environment for complex skills.

However, additional research into the effect of synchronous computer-mediated communication on solving complex tasks is necessary. According to Murphy and Collins (1997), research on synchronous computer-mediated communication has been limited to investigations of the recreational use of online chat systems. But the use of these systems for instructional purposes, and specifically for problem-solving tasks, has been

explored only through case studies. These case studies support the hypothesis that the benefits of collaborative environment in a face-to-face environment are also found in a computer-mediated environment (Hall, 1997; Johnston, 1996; Naidu & Oliver, 1999).

Current research on computer-mediated collaborative learning indicates that it is effective when students are faced with higher-order cognitive tasks such as problem solving (Johnston, 1996). In a short pilot study on the use of computer-mediated collaborative groups in post-compulsory teacher education in the United Kingdom, results indicated that students using computer-mediated communications worked better with higher-order cognitive tasks than students in the control group who collaborated face-to-face (Hall, 1997). In another case study where collaborative learning facilitated through computer-communication was used, nurse practitioners appeared to derive more benefit from the experience of their peers by working and sharing information via computer-mediated communications than a group of students who did not have access to computer-mediated communication (Naidu, et.al., 1999).

Other research also indicates that the quality of interaction between learners in a computer-mediated environment may actually be better than interaction in a face-to-face environment. Findings in a case study suggested that computer-mediated groups seemed to put more thought into the comments they made, thus providing higher quality responses than students who worked face-to-face (Camin, Hall, Quarantillo & Merenstein, 2001). Hillman (1999) also found that the interaction patterns of computer-mediated groups resembled thoughtful discussions whereas face-to-face interactions resembled recitations. And in yet another study where computer-mediated

communications was compared to face-to-face interactions, findings suggest that in the computer-mediated environment there was a tendency to share ideas without the restraints of typical social conventions, which resulted in deeper and more thoughtful discussions (Kruger & Cohen, 1996).

In a recent study that compared computer-mediated collaboration versus individual learning, Uribe, Klein and Sullivan (in press) found that learners who collaborated through a synchronous computer-mediated environment to resolve an ill-defined problem performed significantly better than learners who worked alone. These results support the hypothesis that computer-mediated collaboration has a positive effect on performance when resolving ill-defined problems. The results also showed that, overall, learners preferred to work collaboratively versus individually. Another interesting finding was the high number of on-task interactions (questions, answers and discussions) between members of the dyads, which seems to support the idea that a computer-mediated collaborative environment promotes peer-to-peer communication directly related to the learning task.

Computer-Mediated Collaborative Group Size

Another variable that may influence achievement in a computer-mediated collaborative setting is the size of the collaborative group. Although little empirical exploration exists on this subject (Collins & Onweugbuzie, 2000;Valcke, 1988), the general rule-of-thumb is that small collaborative groups (2-4) are better than large groups (Johnson & Johnson, 1988). The studies that have been conducted addressing this question have yielded contradictory results. For example, Lou, Abrami and d'Apollonia

(2001) conducted a meta-analysis of 122 studies that compared small group and individual learning with computers and found that groups of two had significantly higher achievement than groups of three to five members. Collins & Onweugbuzie (2000) discovered that group size had a quadratic effect on the quality of output produced in a face-to-face undergraduate research methodology class. This quadratic effect meant that teams of two outperformed the teams of three, four and five participants, but the team of six members outperformed all teams. But the researchers point out that since the interactions between team members were not recorded, it is unclear whether group size was the only factor that affected performance (Collins & Onweugbuzie, 2000).

However, Lotan, Cohen, and Hothuis (1994) found somewhat different results in a naturalistic study in which 7th and 8th grade students were observed working on ill-defined problems with open-ended solutions in social studies classes. In this study no groups were assigned, but the students were allowed to form into spontaneous working groups. The observations revealed that groups with the higher number had the highest level of participation and the highest average achievement. The researchers concluded from the observation data that the larger the group size, the larger the proportion of students interacting. Alternatively, McIsaac and Ralston (1996) observed a distance education undergraduate course and found that collaborative groups larger than five in synchronous environments may require a moderator to be effective. However, it is important to point out that the students observed by McIsaac were involved in classroom discussions and not working on problem-solving tasks.

The size of a computer-mediated collaborative group in synchronous environments is particularly important to consider when solving complex tasks. The most commonly used form of synchronous computer-mediated communication in distance education settings is some form of text-based communication, such as the Internet Relay Chat. An obvious advantage of this type of system is that participants can communicate real-time without the delay experienced in asynchronous systems like email or listservs. A synchronous communication system is also better suited for problem-solving tasks because it more closely resembles a real-world situation (Bastiaens & Martens, 2000). But, according to Murphy and Collins (1997), one of the biggest disadvantages of chat-systems is that turn taking in this synchronous environment can be a problem because there are no visual clues such as body movements, eye-contact, etc., to indicate when someone wants to enter a conversation. In this type of system, all of the users tend to "talk" simultaneously and several conversations may be occurring at the same time, creating a confusing environment. Thus, as the number of members of a synchronous computer-mediated collaborative group increases, the positive effects of collaboration when solving complex tasks may decline. The confusion created by a larger number of participants may have a detrimental effect on the group's ability to solve problems.

Research Questions

This study examined the effects of two instructional methods (case-based approach and systematic approach) and collaborative group size (teams of two or four) on learner performance in solving ill-defined problems. The case-based approach provided a

learner with a current state (problem), end-state (goal) and a solution to the problem. The systematic approach confronted the learner with a problem but taught a step-by-step process that could be used to solve it. Data on performance solving ill-defined problems, attitudes, and time on task were collected for all participants. Data were also collected on the nature of the interactions between participants in both sizes of collaborative groups. The processes used by participants to arrive at a solution were also observed. The research questions for this study were:

1. Do either instructional method (case-based approach vs. systematic approach) or collaborative group size (dyads vs. quads) have an effect on learner performance in solving ill-defined problems in a web-based environment?
2. Do either instructional method or collaborative group size have an effect on time spent on instruction?
3. Do either instructional method or collaborative group size have an effect on time spent solving problems?
4. Do either instructional method or collaborative group size have an effect on learner attitudes toward collaborative learning, computer-mediated collaboration, web-based instructional programs, time available for the program, and applicability of problem-solving skills learned to other tasks?
5. Do either instructional method or collaborative group size have an effect on the type and amount of communication that takes place between team members?

Method

Participants

The participants in this experiment were 130 cadets from the United States Air Force Academy. All of the participants volunteered to participate in the study. There were 99 male participants (75%) and 31 female participants (25%). The study was incorporated into a three-hour segment of instruction of the cadets' first-year language course. Although the participants' academic ability was not measured, they were expected to be high academic achievers since the Air Force Academy has very high entrance requirements.

Materials

The materials for this study were developed and incorporated into a web-based interface through the Blackboard course management system (see Figure 1). Blackboard is a course management system that provides faculty members the ability to develop and deliver courses over the World Wide Web. The following items were embedded within the Blackboard system for this study: an instructional program, problem scenarios and assessment questions relating to the problem scenarios.

Instructional Programs. Two different web-based instructional programs were developed for this study. One program taught the participants a systematic approach to solve problems. Another program used a case-based approach to teach students how to

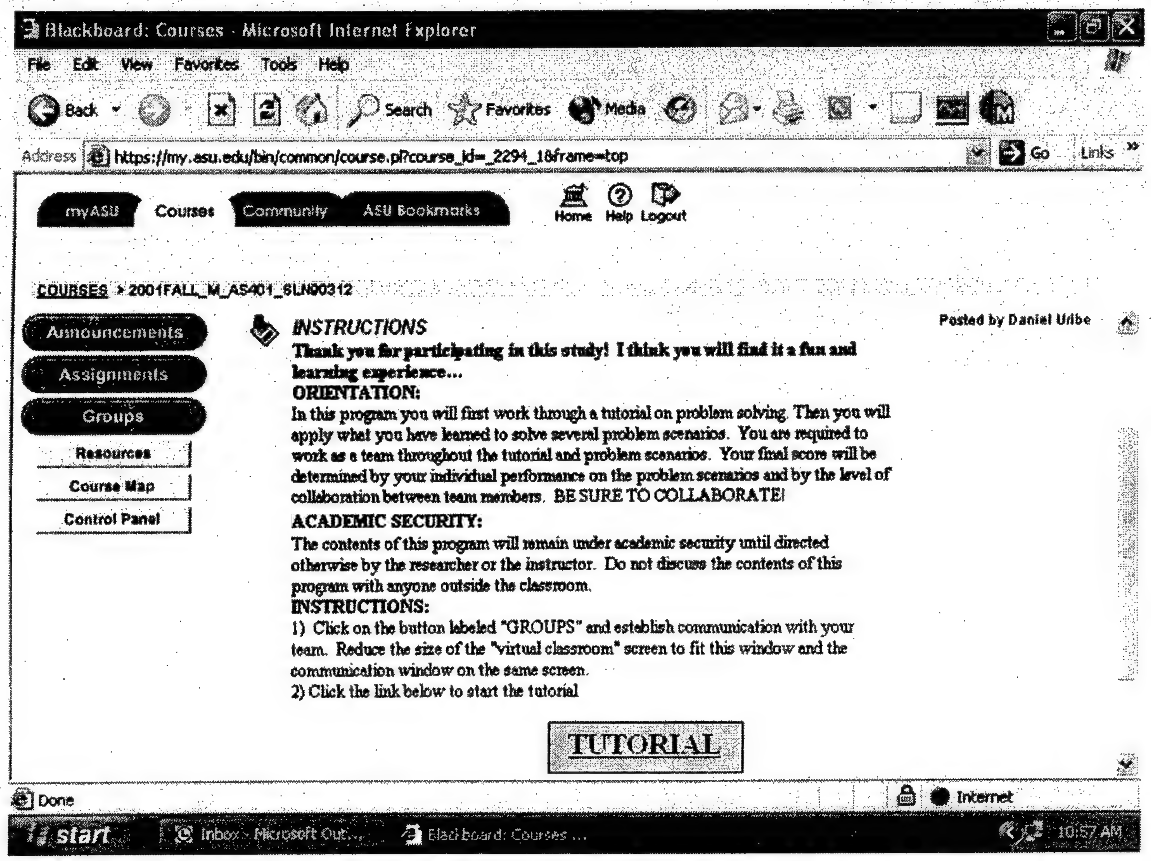

Figure 1. Blackboard Interface and welcome screen.

solve problems. Both programs taught students how to solve decision-making problems. A description of each instructional program is presented below.

Systematic Approach: A web-based instructional program on a systematic approach to problem solving was developed for this study (see Appendix A). The instructional program focuses on a four-step problem-solving process derived from the Air Force's "Six-Step Problem-Solving Process" commonly taught to college juniors enrolled in the Air Force ROTC program. This modified approach was intended to provide students with a tool to solve complex problems. The systematic instructional approach was also developed based on principles for systematic problem solving outlined by Gagné (1985) and Van Merrienboer et al (2002). The learning objectives of the program were for the student to:

1) Describe the problem environment and write a problem statement.
2) Categorize data relative to the problem.
3) Identify possible solutions that meet the problem criteria.
4) Select the best possible solution.

The problem-solving process led students through the following four steps: problem definition, data gathering, developing and testing possible solutions, and selection of the best possible solution. Within the program, an agent (animated cartoon) taught the steps of the process and used an example scenario to show the learner how to apply each step. Throughout this portion of the instructional program, the learner was asked to discuss the information in each step of the process with the rest of his or her team. For example, during the instruction for step one the learner was taught that it is

important to identify the individuals involved in the problem. He or she was then asked to discuss with his or her team who the individuals involved in the problem are and to write an answer in a space provided. The animated cartoon then showed the learner the correct answer.

The teaching of the steps was followed by a second practice scenario where the student was presented with the problem and was asked to find the best possible solution. In total, the student was exposed to two different problem scenarios in the instructional program. The learner was prompted to collaborate with his or her team at several points throughout the learning program.

Case-Based Approach: A web-based instructional program that uses a case-based approach for problem solving was also developed for this study (see Appendix B). The program was designed using the principles outlined by Van Merrienboer et al. (2002) for using case studies to teach problem solving. The program was designed as an open-ended learning environment but with some constraints. The first screen welcomed the student and quickly familiarized him/her with the web interface. The student was then told that he or she would be learning how to solve complex problems by reading how others have solved similar problems.

The content of this case-based instructional program had some similarities and key differences with the content of the systematic approach to problem solving described above. The same two problem scenarios were used and an animated agent also guided the learner. However, the student was not systematically taught the four steps of the problem learning process. Instead, as Van Merrienboer et al. (2002) suggest, the learner

was confronted with a given state (problem scenario), a desired state (goal) and a best possible solution as determined by the individual involved in the case. For example, the participant was confronted with a problem scenario where a cadet is facing a decision-making problem (given state). The agent "leads" the learner as he implements a solution based on the information surrounding the problem to achieve a goal (desired state). As recommended by Van Merrienboer, et al. (2002), the learner was asked several thought-provoking questions throughout the program, which were intended to trigger deep processing and to develop a better mental model of the problem environment. For example, after the learner read the problem scenario the learner was asked to discuss the following questions with his or her team: "Can you think of possible solutions to this problem? What other information would you need to make a decision?" After the agent developed possible solutions, the learner was asked, "What do you think of my possible solutions? Do you think my solutions address the problem? Why or why not?" Finally, after the participants read what happened when a solution was implemented, they were asked to discuss the following question, "Would you consider this an acceptable outcome? Why or why not?"

Once the learner went through one case study he or she had an opportunity to practice with a different problem scenario. In the practice exercise, the learner was presented with a scenario and information related to the scenario. The learner was asked to collaborate with his or her partners to identify the best possible solution based on the information available. The feedback the learner received in the program was based on a list of "expert" solutions for the scenario generated from studies conducted by Hedlund,

Sternberg and Psotka (2002) for the Army Research Institute. In this case-based approach, learners were given the same two problem scenarios as learners in the systematic approach and the same amount of practice. The key difference between the two instructional programs was the approach used. As previously noted, the participants were asked to collaborate at several points throughout both instructional programs.

Assessment Problem Scenarios. The assessment scenarios that were used in the instructional programs and for assessment were modified versions of scenarios developed by Hedlund et al. (2002) of the Army Research Institute (see Appendix C). The participants reached the problem scenario through the screen shown on Figure 2. The problem scenarios were developed from realistic situations encountered by junior Army officers and were modified by the researcher to reflect an Air Force theme. The modifications included changing items such as Army company commander to Air Force squadron commander or changing a tactical scenario involving soldiers to tactical scenarios involving airmen. There were no substantial changes made to the problems faced by the young officer or the circumstances surrounding it. All of the problem scenarios revolved around a military theme.

All treatment groups were assessed using the same problem scenarios. The following is an example of the types of problem scenarios that were used:

"You are a new element leader. Your squadron is preparing to deploy as part of a rapid-response contingency TDY. You assemble your element and tell everyone to start

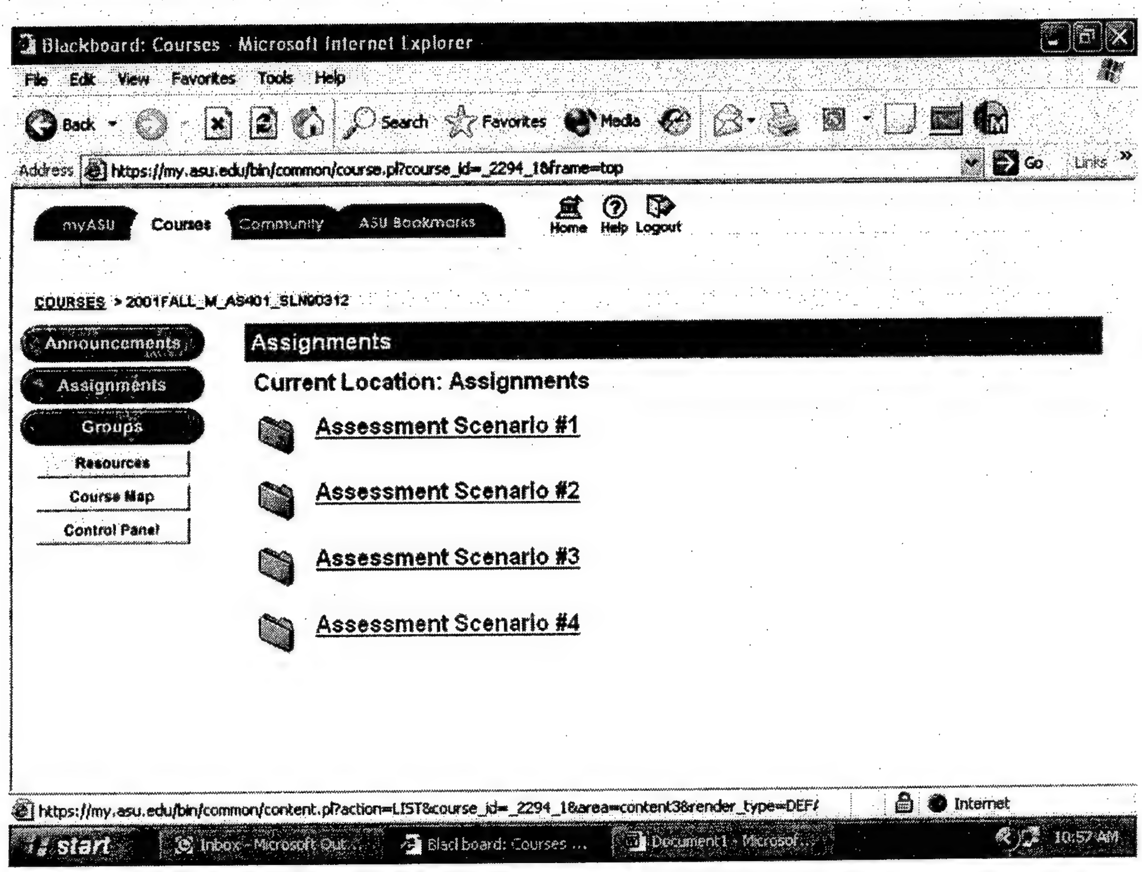

Figure 2. Blackboard Interface for Assessment Scenarios.

packing equipment in preparation for the deployment that same night. When you come back to inspect their deployment preparation, you find that your airmen have not packed the equipment and are talking to personnel from other elements who are hanging around the area. What should you do?"

As part of the problem scenario, the participants had access to additional information in the form of simulated interviews with the individuals involved in the problem scenario. The collaborative groups were able to discuss the problem scenario and related information. However, each member of the group had to answer each assessment question individually. The question the students had to answer for each problem scenario is listed below:

"What is the BEST POSSIBLE solution for this problem? Make sure to FULLY EXPLAIN the rationale you used to develop your solution."

Scoring Rubric. A scoring rubric (Appendix D) was used to evaluate the participants' responses to the assessment scenarios. Given the nature of an ill-defined problem scenario, there were a variety of optimal solutions for each problem scenario. Therefore, the rubric was constructed to allow assessment of the validity of the solution proposed by the learner, and the quality of the process the student used to arrive at the solution. The rubric was designed to help evaluate learner performance in the following areas:

1) Current state or problem definition (Did the learner understand what the problem is?)
2) End state or goal (Did the learner understand what the desired goal is?)
3) Process (Did the learner follow a logical, well-supported path to achieve a solution?)
4) Recommended solution (Did the solution produce the desired end-state? Is it the best possible solution given the learner's understanding of the problem?)

The participants were given four problem scenarios to solve, however, they were told to concentrate on solving the first two scenarios and only do the last two scenarios if there was extra time available. Problems three and four were considered bonus problems. In order to emphasize the quality of responses on the first two scenarios and encourage collaboration, they were told that the first two scenarios were worth 8 points, while the bonus problems were only worth one point each. The maximum score possible for problems one and two was 16 points. Although the participants collaborated on the problem scenarios, each participant provided individual responses to each problem. The participants overall score was determined by the total number of points earned for each scenario. As a hypothetical example, if participant A was able to complete all four scenarios but the quality of the responses was low, participant A may have earned four points on scenario #1, three points on scenario #2, one point for bonus scenario #3 and zero points for bonus scenario #4. The total score for participant A was 8 points. Alternatively, if participant B completed only the first two scenarios but the quality of the responses was high, he or she may have scored eight points for scenario #1, seven points

for scenario #2 and zero points for the bonus problems. However, the overall score of participant B would be higher than participant A's with a total of 16 points.

The participant answers to the assessment scenarios were graded by the primary researcher and another individual trained by the researcher on the scoring rubric and assessment scenarios. The primary researcher is an Air Force major with 16 years of experience dealing with problems related to technical troubleshooting, decision-making, and leadership and is well-qualified to assess the quality of responses of the participants. The additional rater holds a Bachelor of Science in business administration and has 15 years of workplace and business experience. The inter-rater reliability was established by having the primary rater and additional rater blind score the problem scenarios for ten participants. The scores for each assessment scenario were loaded into SPSS for each of the ten participants and analyzed to determine the correlation between the two raters. The correlation was found to be .94. Once the inter-rater reliability was established, the two raters scored an equal number of participant responses.

Attitude Survey. A 22-item survey was developed to measure participant attitudes toward working with one or three partners, as well as their attitude toward the instructional program and toward transfer of the problem solving skills learned to other tasks (see Appendix E). The survey contained 18 Likert-scale items, one multiple choice question and three open-ended questions. Respondents used a four-point Likert scale (0=strongly disagree, 3=strongly agree) to rate their attitude toward working in a web environment, working with others when solving problems, and their perception of transfer of their problem-solving skills to other types of tasks. Coefficient alpha was

computed as an internal consistency estimate of reliability for the Likert portion of the survey and found to be .83. The18 questions of the Likert portion of the survey were divided into six different categories with three questions each. These six categories were intended to gauge participant attitudes towards working with others, collaborating on-line, appeal of instructional materials, amount learned from instructional materials, time available for the program and applicability of information learned to other settings. A factor analysis was performed on these 18 questions to determine if the survey data revealed the same categories or groupings. This procedure yielded five factors. The identified underlying themes were participant attitudes toward: 1) working with others, 2) collaborating on-line, 3) instructional materials, 4) time available for the program, and 5) transfer of the information learned to other settings. The procedure used for factor extraction is discussed in the design and data analysis section below. Additionally, the participants were asked to select their preference for working on complex problems from the following four choices: alone, with one partner, with two partners, or with three or more partners. The participants were also asked to write down the process they used to solve the problems, what they liked best about the program, and what they would do to improve the program.

Procedures

In accordance with the requirements of the Air Force Academy Institutional Research Board, one week prior to the study, the primary researcher went into every first-year Spanish, French and German classroom and read a recruitment script (Appendix G), which explained the purpose of the study in general terms, described that the top-

performing teams would receive a free dinner, and requested volunteers for the study. The primary researcher conducted the briefings in civilian clothes to preclude the possibility of subtle coercion of the cadets. Once the cadets had made a decision, those who decided to participate were given a copy of the "Subject's Bill of Rights" (Appendix H) and were asked to read and sign an Informed Consent Document (Appendix I).

Immediately following the recruitment portion of the briefing, the cadets who volunteered for the study were given approximately 20 minutes of instruction on login procedures for the Blackboard system, how to use the Blackboard system to collaborate, and general instructions on how to navigate throughout the program. Any technical issues related to access to the Blackboard system were clarified during this briefing. Finally, the participants were given a problem scenario and were asked to write-down the process they would use to solve the problem (see Appendix F). This instrument provided information on whether the participants had previously learned a process for problem-solving.

After the recruitment briefings were completed and a list of volunteers was generated, the participants were randomly assigned to one of four treatment groups. The treatment groups were divided by instructional method and collaborative group size as follows:

Group 1: Systematic Approach - Dyads

Group 2: Systematic Approach - Quads

Group 3: Case-Based Approach - Dyads

Group 4: Case-Based Approach - Quads

The first day of the study, the participants were given a card which included their username, password, and collaborative group number as they came into the laboratory. They were then directed to pre-arranged locations in the computer laboratory, which ensured that each member of a team was physically separated from his or her partners. This procedure was carried out to prevent verbal or bodily communications between the members of the teams, thus simulating a distance- education environment. At each station, each participant also had access to a hard copy of the on-screen instructions. Figure 3 shows the physical layout of the laboratory and some of the participants at their assigned stations. The participants were verbally instructed to sign-on to the Blackboard system using their assigned username and password and to navigate to the study's web page. Once everyone was properly logged-in to Blackboard, the researcher told them to follow the instructions on the screen and informed them that they had until the end of the class period to work on the program.

The first screen of the web-based program instructed the participants on how to collaborate with their partners. The instructions reminded them that although they were answering the questions individually, they would also have a team score. The instructions explained that a high level of collaboration would result in a higher group score. At this point the participants were also reminded to concentrate on the first two assessment scenarios and only work on the last two scenarios if there was time available. The communication between members of the teams took place using the virtual classroom feature of the Blackboard system (see Figure 4). This feature allowed students to chat with their partners by entering a virtual classroom that the researcher set up for

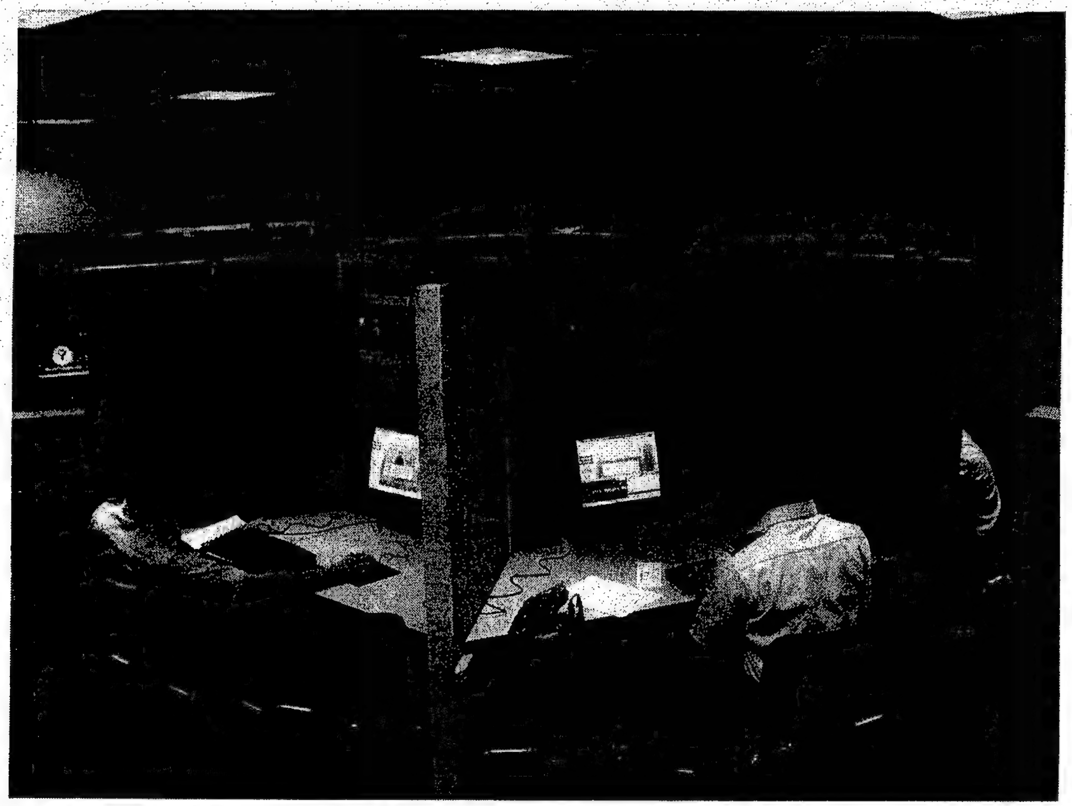

Figure 3. Study participants at their assigned workstations

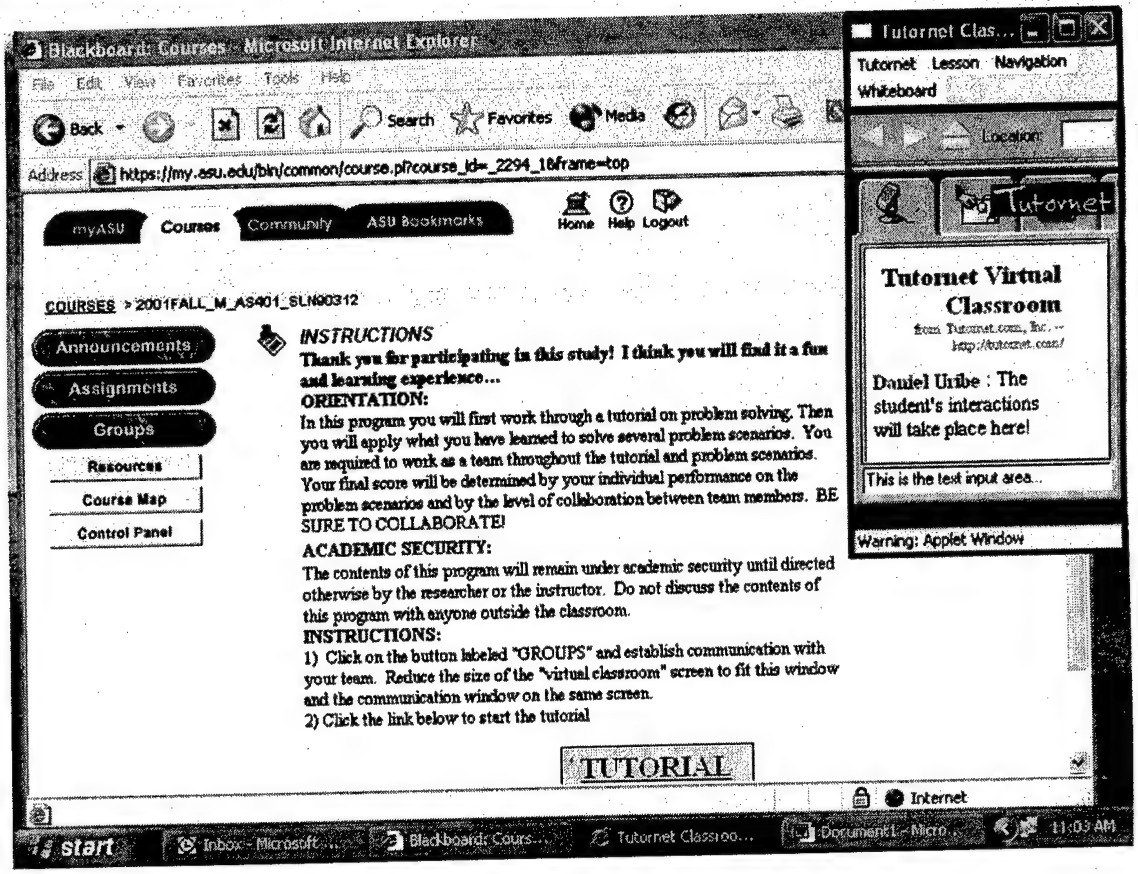

Figure 4. Blackboard Interface with Virtual Classroom window.

each team prior to the start of the study. Each team was assigned a different virtual classroom to prevent cross-flow of information between teams. There were no interactions between the participants and the researcher and/or instructors during the study except to remedy any technical difficulties.

Design and Data Analysis

This study was a posttest only 2 (case-based approach vs. systematic approach) x 2 (collaborative group size: 2 vs. 4) factorial design. The primary dependent variable was student performance in solving ill-defined problem scenarios. Time on learning task, time on problem-solving task, number of problems solved, and learner attitudes were also analyzed. An analysis of the interactions between the members of the collaborative teams was also conducted.

A 2 x 2 analysis of variance (ANOVA) were conducted on participants' performance on assessment scenarios one and two, time on learning task, and time on problem-solving task with treatment group and group size as the independent variables. A Wilcoxon repeated measures test was also performed on problems one and two to determine if performance was significantly different between the two scenarios. Descriptive statistics for the number of participants who completed bonus problems three and four were also computed.

An internal consistency of reliability was calculated on the 18 Likert-type items of the survey. Then, using the procedures outlined in Green, Salkind & Akey (2000), a factor analysis was conducted to determine any underlying themes in the survey. The number of underlying factors was determined using all items with eigenvalues greater

than one. The factors were then rotated using the VARIMAX method in order to interpret the results. This method identifies the underlying themes or factors by highlighting the items most highly correlated with each other.

The first factor ("working with others") included items one through three. The second factor (collaborating on-line) included items four through six. The third factor ("instructional materials") included items seven through twelve. The fourth factor ("time available for the program") included items thirteen through fifteen. And factor number five ("transfer of the information learned to other settings") included question seventeen and eighteen. Survey item sixteen ("The scenarios in this program were realistic and applicable to a future Air Force career") did not correlate with any other question and was therefore not included in any of the five factors. An average score for each factor was computed and separate 2 x 2 ANOVAs were then conducted on each factor.

Chi-square tests were conducted on the multiple-option question:

When solving complex problems, I prefer to work

a. By myself

b. With one partner

c. With two partners

d. With more than two partners

A two-way contingency table analysis was used to determine if a significant relationship existed between treatment group and the preferences expressed by the participants. Additional chi-square tests were conducted by treatment group.

Finally, the interactions between members of the teams were analyzed using both qualitative and quantitative analysis techniques. The interactions between team members were automatically recorded by the Blackboard system. These data were then categorized by type of interaction. For example an entry was classified as a "question", "answer", "discussion", "encouragement" or "off-task behavior." Previous researchers have used similar categories in studies examining small group interactions (Klein & Doran, 1999; Klein & Pridemore, 1994; Uribe, et al, in press). A percentage for each category was computed and a two-way contingency table analysis was conducted on the data to evaluate if a significant relationship existed between type of interaction and treatment group. Follow-up pairwise comparisons were conducted to evaluate the differences between treatment groups. The Holm's sequential Bonferroni method was used to control for Type I error.

Results

Performance by Instructional Method and Group Size

The first two research questions investigated the effect of instructional method and group size on performance in solving ill-defined problems. Table 1 shows the mean scores and standard deviations for performance on assessment scenarios one and two. Due to a problem with the server hosting the Blackboard program, some of the performance data were lost resulting in uneven cell sizes. The table reveals that on problem one participants averaged 3.12 out of 8 points (39%), $SD = 1.83$, while the average score on problem two was 4.04 (51%), $SD = 1.82$. A Wilcoxon test conducted on these data showed that participants obtained significantly higher scores on problem two than on problem one, $z = -4.0$, $p < .001$.

When examined by group size, participants who worked in dyads had an overall average of 3.45 (43%), $SD = 2.94$ on problem one and 4.12 (52%), $SD = 1.91$ on problem two. Participants who worked in groups of four had an average of 2.76 (35%), $SD = 1.62$ on problem one and an average of 3.96 (50%), $SD = 1.74$ on problem two. The data also show that participants who used the systematic approach had an overall average of 3.07 (38%), $SD = 1.83$ for problem one and scored 4.28 (54%), $SD = 2.08$ on problem two. Participants who used the case-based approach had an overall

Table 1.

Mean scores and standard deviations for performance on problems 1 & 2

Group Size		Instructional Method					
		Systematic		Case-Based		Overall	
		Prob 1	Prob 2	Prob 1	Prob 2	Prob 1	Prob 2
Dyads	Mean	3.31	4.73	3.56	3.65	3.45	4.12
	(SD)	(1.89)	(2.22)	(2.02)	(1.49)	(1.95)	(1.91)
	n	26	26	34	34	60	60
Quads	Mean	2.86	3.86	2.67	4.07	2.76	3.96
	(SD)	(1.78)	(1.88)	(1.47)	(1.61)	(1.62)	(1.74)
	n	28	28	27	27	55	55
Overall	Mean	3.07	4.28	3.16	3.84	3.12	4.04
	(SD)	(1.83)	(2.08)	(1.84)	(1.55)	(1.83)	(1.82)
	n	54	54	61	61	115	115

Note. The maximum number of points on each problem scenario was 8

average of 3.16 (40%), SD = 1.84 on problem one and scored 3.84 (48%), SD = 1.55 on problem two.

A 2 x 2 ANOVA conducted on the data for problem one revealed that participants working in dyads had a significantly higher performance score than those working in quads, $F(1,111) = 3.9, p = .05$, partial $\eta^2 = .034$. There was not a significant difference by instructional method, $F(1,111) = .01, p = .93$, partial $\eta^2 < .001$, and there was no significant interaction, $F(1,111) = .42, p = .52$, partial $\eta^2 = .004$. A 2 x 2 ANOVA conducted on the data for problem two revealed that there was no significant difference by instructional method, $F(1,111) = .44, p = .51$, partial $\eta^2 = .004$, or by group size, $F(1,111) = 1.65, p = .20$, partial $\eta^2 = .015$. The data also showed there was not a significant interaction present, $F(1,111) = 3.71, p = .06$, partial $\eta^2 = .032$.

When the scores for problems one and two are combined, the data reveal that the overall scores for problems one and two was 7.17 (45%), SD = 2.82. Participants who worked in dyads scored an average of 7.57 (47%), SD = 2.84, while participants who worked in quads obtained an average score of 6.73 (42%), SD = 2.75. The results by instructional method reveal that participants who used the systematic approach scored an average of 7.35 (46%), SD = 2.76, while participants who used the case-based approach earned an average of 7.17 (45%), SD = 2.88. ANOVA conducted on these combined scores did not indicate a significant difference by group size, $F(1,111) = 2.89, p = .09$, partial $\eta^2 = .025$, or by instructional method, $F(1,111) = .59, p = .45$, partial $\eta^2 = .005$, and there was no significant interaction, $F(1,111) = .67, p = .42$, partial $\eta^2 = .006$.

Although performance on the bonus problems (problems three and four) were not included in the analyses above, data were collected on the number of participants who completed these problems. These data revealed that of the 54 participants who used the systematic approach, 48 (89%) completed problem three and 29 (54%) completed problems three and four. Of the 61 participants who used the case-based approach, 46 (75%) completed problem three and 37 (61%) completed problems three and four. The data also show that of the 60 participants who worked in dyads, 52 (87%) completed problem three, while 41 (79%) completed problems three and four. Of the 55 participants who worked in quads, 42 (76%) completed problem three and 25 (60%) completed both bonus problems.

Time spent on instruction

The next research questions pertained to the effect of instructional method and group size on time spent on instruction. As was the case with the performance data, intermittent problems with the server caused a loss of some time data. In addition to these losses due to technical problems, four participants whose times exceeded three standard deviations from the mean were considered outliers and were excluded from the time-on-task analyses. The losses and elimination of these data resulted in different cell sizes for the time-on-task analysis.

The data in Table 2 show that participants spent an overall average of 31.3 minutes, $SD = 13.59$, on the tutorial. When analyzed by group size, the data revealed that participants who worked in dyads spent an average of 29.2 minutes, $SD = 12.8$, while participants who worked in quads spent an average of 33.7 minutes, $SD = 14.1$. When

Table 2.

Mean times and standard deviations for time on the tutorial

Group Size		Instructional Method: Systematic	Instructional Method: Case-Based	Overall
Dyads	Mean	28.7	29.5	29.2
	(SD)	(11.3)	(14.1)	(12.8)
	n	26	34	60
Quads	Mean	29.2	38.2	33.7
	(SD)	(11.7)	(15.0)	(14.1)
	n	27	27	54
Overall	Mean	28.9	33.4	31.3
	(SD)	(11.4)	(15.0)	(13.6)
	n	53	61	114

examined by instructional method, the participants who used the systematic approach tutorial spent an average of 28.9 minutes, $SD = 11.4$, while participants who worked through the case-based tutorial spent an average of 33.4 minutes, $SD = 15.0$. A 2 x 2 ANOVA indicated that participants who worked through the case-based tutorial spent significantly more time-on-task than participants who worked through the systematic approach tutorial, $F(1,110) = 3.87, p = .05$, partial $\eta^2 = .03$. There was not a significant difference by group size, $F(1,110) = 3.38, p = .07$, partial $\eta^2 = .03$, and no significant interaction was present, $F(1,110) = 2.63, p = .11$, partial $\eta^2 = .02$.

Time spent solving problems

The next research questions pertained to the effect of instructional method and group size on time spent solving problems. Since the participants were asked to concentrate on problem scenarios one and two, time data were collected and analyzed for these two problems. Server problems also caused some of these time data to be lost, resulting in uneven cell sizes.

Time spent on assessment scenario #1. The data in Table 3 show that the participants spent an overall average of 9.3 minutes, $SD = 3.0$ on assessment scenario one. The data also revealed that participants who worked in dyads spent an average of 9.0 minutes on the assessment scenario, $SD = 3.1$, while participants who worked in quads spent an average of 9.7 minutes, $SD = 2.9$. Additionally, participants who used the systematic approach to solve the problem spent an average of 10.2 minutes, $SD = 3.5$, while participants who solved the problem using the case-based approach spent an average of 8.7 minutes, $SD = 2.5$. A 2 x 2 ANOVA

Table 3.

Mean times and standard deviations for time spent on scenario #1

		Instructional Method		
Group Size		Systematic	Case-Based	Overall
Dyads	Mean	9.5	8.8	9.0
	(SD)	(4.2)	(2.3)	(3.1)
	n	17	30	47
Quads	Mean	10.9	8.7	9.7
	(SD)	(2.5)	(2.8)	(2.9)
	n	17	20	37
Overall	Mean	10.2	8.7	9.3
	(SD)	(3.5)	(2.5)	(3.0)
	n	34	50	84

indicated that participants who used the systematic approach spent significantly more time on the scenario than participants who used the case-based approach, $F(1,80) = 4.86$, $p = .03$, partial $\eta^2 = .06$. There was no significant difference by group size, $F(1,80) = 1.00$, $p = .32$, partial $\eta^2 = .012$, and no significant interaction was present, $F(1,80) = 1.22$, $p = .27$, partial $\eta^2 = .015$. It is important to point out that Levene's test for homogeneity of variance yielded a significant result indicating the possibility this assumption may have been violated. Therefore, some caution should be exercised when interpreting these data.

Time spent on assessment scenario #2. The data in Table 4 show that the participants spent an overall average of 9.5 minutes, $SD = 3.9$ on assessment scenario two. The data also revealed that participants who worked in dyads spent an average of 8.5 minutes on the assessment scenario, $SD = 2.6$, while participants who worked in quads spent an average of 10.6 minutes, $SD = 3.9$. Additionally, participants who used the systematic approach to solve the problem spent an average of 11.7 minutes, $SD = 3.6$, while participants who solved the problem using the case-based approach spent an average of 8.0 minutes, $SD = 2.4$.

A 2 x 2 ANOVA indicated that participants who used the systematic approach spent significantly more time on the scenario than participants who used the case-based approach, $F(1,80) = 27.9$, $p < .001$, partial $\eta^2 = .26$. The data also showed that participants who worked in quads spent significantly more time on the problem than participants who worked in dyads, $F(1,80) = 8.14$, $p < .006$, partial $\eta^2 = .09$. ANOVA

Table 4.

Mean times and standard deviations for time spent on scenario #2

Group Size		Instructional Method: Systematic	Instructional Method: Case-Based	Overall
Dyads	Mean	9.6	7.9	8.5
	(SD)	(3.2)	(2.0)	(2.6)
	n	14	29	43
Quads	Mean	13.1	8.1	10.6
	(SD)	(3.1)	(3.0)	(3.9)
	n	21	20	41
Overall	Mean	11.7	8.0	9.5
	(SD)	(3.6)	(2.4)	(3.9)
	n	35	49	84

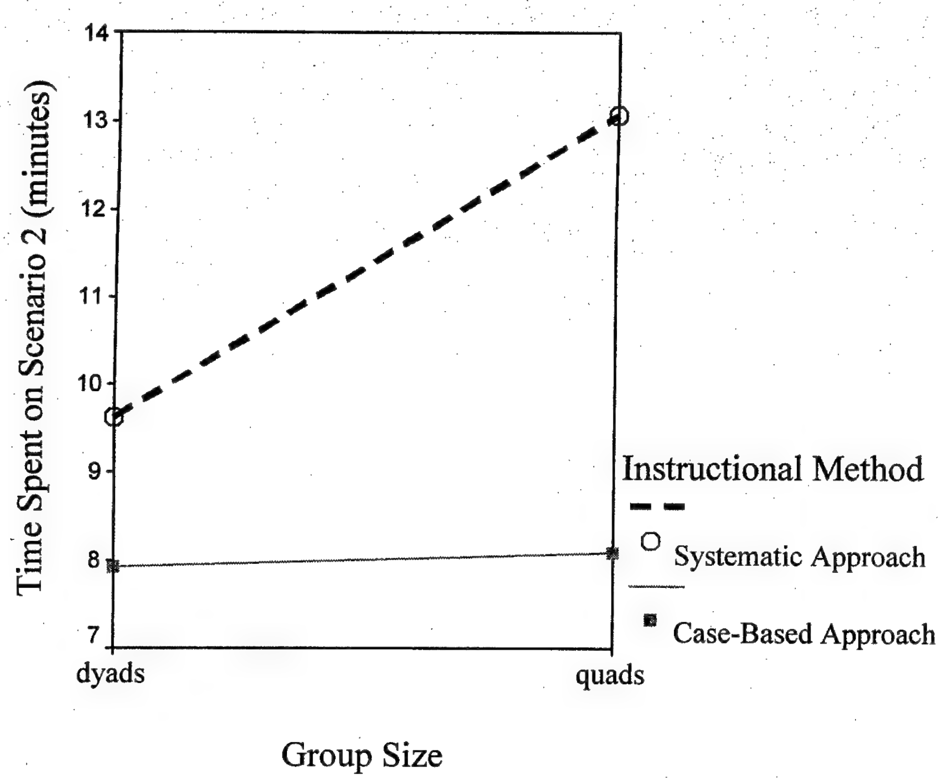

Figure 5. Interaction between method and group size for time on problem #2

also indicated a significant interaction between group size and instructional method, $F(1,80) = 6.83, p = .01$, partial $\eta^2 = .08$ (see Figure 5). Follow-up analyses were conducted to evaluate the two simple main effects for instructional method and collaborative group size. To control for Type I error across the simple main effects, I set alpha for each test at .025 (.05/2). The results revealed a significant difference between participants who worked in dyads (M=9.6, SD = 3.3) and those who worked in quads (M =13.1, SD = 3.2) using the systematic approach, $F(1, 80) = 12.8, p = .001$. The analysis also showed that for participants who worked in quads, there was a significant difference between participants who used the systematic approach (M =13.1, SD = 3.2) and those who used the case-based approach (M =8.1, SD = 3.0), $F(1, 80) = 32.5, p < .001$. The analysis did not reveal a significant difference between dyads and quads using the case-based approach, $F(1, 80) = .04, p = .852$, and there was no significant difference between dyads who used the systematic approach and dyads who used the case-based approach, $F(1, 80) = 3.43, p = .068$.

Participant Attitudes

The next research question investigated the effect of instructional method and group size on participant attitudes. The survey included 18 Likert items, one multiple-option question and three open-ended questions. The 18 Likert items in the survey were rated by the participants on a scale from zero to three (0 = Strongly Disagree, 1 = Disagree, 2 = Agree, 3 = Strongly Agree). An internal consistency estimate of reliability for these items was computed to be .83. Factor analysis of the 18 survey items revealed five factors or underlying themes in the survey questions. The five identified factors

were attitudes toward: 1) working with others, 2) collaborating on-line, 3) instructional materials, 4) time available for the program, and 5) transfer of the information learned to other settings. Item number 16 in the survey ("The scenarios in this program were realistic and applicable to a future Air Force officer") did not correlate with any other item in the survey and it was not included in any of the five factors mentioned above. However, it is important to note that this item was the highest rated item in the survey with an average rating of 2.61.

An average rating per factor was computed by summing the scores for each item in the factor and dividing by the number of items. Table 5 shows the results for each of the five factors for each independent variable. The data reveal that participants rated factor number one highest ("working with others"), $M = 2.22$, $SD = .51$ and factor two ("collaborating on-line") lowest with an overall average of 1.68, $SD = .76$. A 2 x 2 ANOVA of each factor revealed mixed results. Factor one (working with others) did not reveal a significant difference by method ($F(1,107) = .002$, $p = .96$, partial $\eta^2 < .001$), group size ($F(1,107) = .29$, $p = .59$, partial $\eta^2 = .003$), and there was no significant interaction ($F(1,107) = 1.06$, $p = .31$, partial $\eta^2 = .01$). The data for factor two (collaborating on-line) did not show a significant main effect for group size or instructional method, but it did reveal a significant interaction, $F(1,107) = 7.02$, $p = .009$, partial $\eta^2 = .06$ (see Figure 6). Follow-up simple main effects analysis revealed a significant difference between participants who worked in dyads (M=1.44, $SD = .76$) and those who worked in quads (M=1.89, $SD = .75$) using the systematic approach, $F(1, 107) = 5.1$, $p = .025$. There were no significant differences for the other simple main

Table 5.

Means and standard deviations for each attitude survey category

Attitude Factor		Systematic Approach (*n*=54)	Case-Based Approach (*n*=57)	Dyads (*n*=56)	Quads (*n*=55)	Total (*n*=111)
1. Working with others	Mean SD	2.22 .56	2.22 .46	2.24 .53	2.19 .48	2.22 .51
2. Collaborating on-line*	Mean SD	1.67 .78	1.68 .74	1.64 .79	1.72 .73	1.68 .76
3. Instructional materials	Mean SD	1.95 .53	1.93 .44	1.96 .56	1.92 .41	1.94 .49
4. Time available for the program**	Mean SD	2.06 .58	1.96 .57	2.13 .55	1.89 .58	2.01 .58
5. Transfer of the information learned to other settings.	Mean SD	2.17 .48	2.03 .53	2.05 .58	2.15 .42	2.09 .51

Note. Responses were on a scale of 0 to 3 where 0 = Strongly disagree, 1 = Disagree, 2 = Agree and 3 = Strongly agree. * Significant interaction, $p = .009$, **Significant main effect by group size, $p = .026$

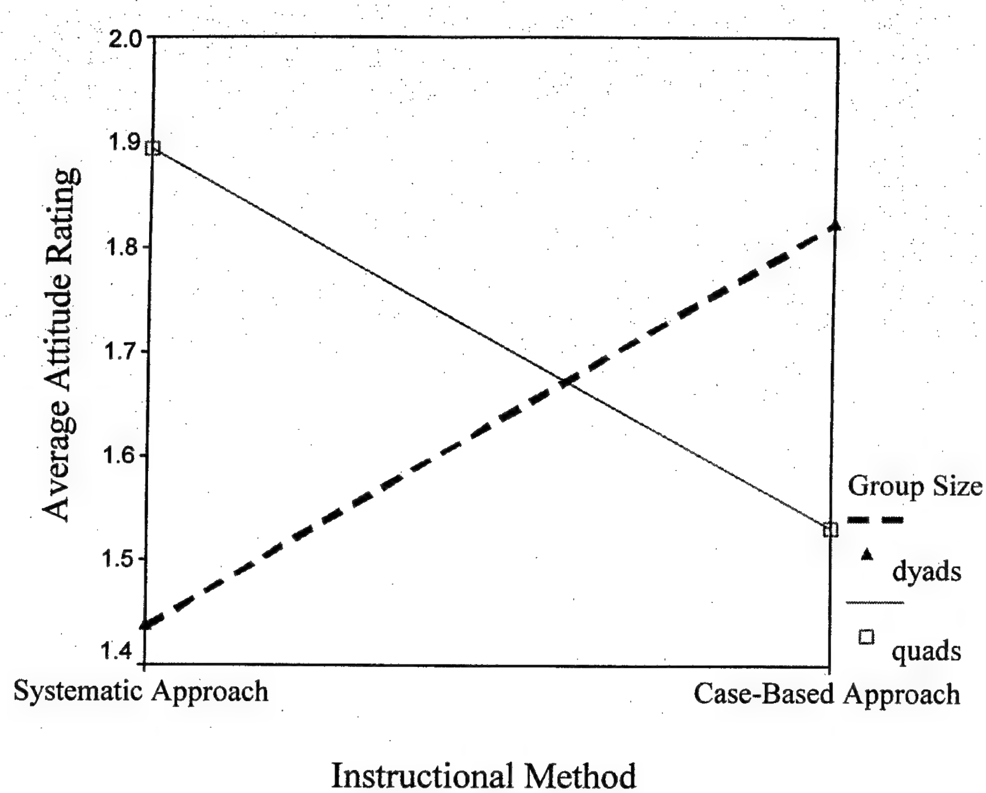

Figure 6. Significant Interaction for factor two ("collaborating on-line")

effects comparisons. Factor three (instructional materials) did not indicate a significant difference by instructional method ($F(1,107) = .332, p = .56$, partial $\eta^2 = .003$), by group size ($F(1,107) = .317, p = .58$, partial $\eta^2 = .003$) or a significant interaction ($F(1,107) = .176, p = .675$, partial $\eta^2 = .002$). Factor four (time available for the program) indicated a significant main effect by group size, $F(1,107) = 5.09, p = .026$, partial $\eta^2 = .05$. There was no significant difference by instructional method ($F(1,107) = 1.01, p = .32$, partial $\eta^2 = .01$), or a significant interaction ($F(1,107) = .37, p = .55$, partial $\eta^2 = .003$). Finally, the analysis for factor five (transfer of the information learned to other settings) did not indicate a significant difference by instructional method ($F(1,107) = 2.01, p = .16$, partial $\eta^2 = .018$), by group size ($F(1,107) = .99, p = .32$, partial $\eta^2 = .001$), and there was no significant interaction ($F(1,107) = .18, p = .68$, partial $\eta^2 = .002$).

Participant Preferences. The attitude survey also included one option question that asked the participants to choose a preference when solving complex problems. The choices were:

a. By myself

b. With one partner

c. With two partners

d. With more than two partners

Table 6 shows the choices made the participants by treatment group. The data are also graphically depicted in Figure 7. A two-way contingency analysis of these data indicated

Table 6.

Participant preference when working on complex problems by treatment group

Preference	Treatment Group: System Dyads	System Quads	Case-Based Dyads	Case-Based Quads	Total (%)
Alone	3	3	4	2	12 (11%)
With one partner	11	9	12	7	39 (35%)
With two partners	8	9	9	10	36 (33%)
With more than two partners	3	7	5	8	23 (21%)
Total (%)	25 (23%)	28 (25%)	30 (27%)	27 (25%)	110 (100%)

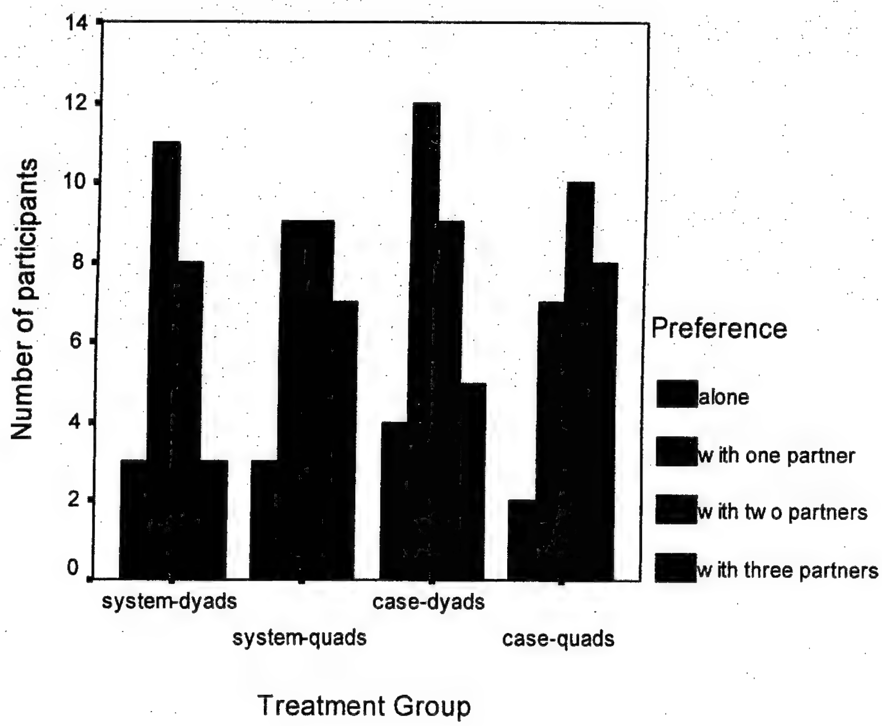

Figure 7. A clustered bar chart of preference for working on complex problems by treatment group.

a non-significant relationship between treatment group and preference, $\chi^2(9, \underline{N}=110) = 4.6$, $\underline{p} = .87$, *Cramer's V* = 0.12. When the preference data is analyzed for all participants regardless of their treatment group, the results show that of the 110 participants who answered this question, 12 (11%) indicated a preference to work alone, 39 (35%) indicated a preference to work with one partner, 36 (33%) prefer to work with two partners, and 23 (21%) indicated they prefer to work with more than two partners when solving complex problems, $\chi^2(3, \underline{N}=110) = 17.6$, $\underline{p} = .001$, *effect size* = +0.16.

Problem-solving process used by the participants. Prior to the treatment the participants were given a simple problem scenario and were asked to state the process they would use to solve it. The responses indicated that 91% (118) of the participants did not know a process or heuristic to solve ill-defined problems. Some of the answers included:

- *"None"*
- *"I would have a talk with the player"*
- *"I would first attempt to talk to the team"*

After the treatment, the participants were asked to state the process they used to solve the problem scenarios. When the responses to this question are analyzed by instructional method, the data show that 51 out of 60 participants who learned the systematic approach indicated they used the approach they learned in the tutorial to solve the problems. Some examples of the responses are:

- *"1) Evaluated the problem; 2) acknowledged who was involved; 3) determined any constraints; 4) brainstormed until a good solution came to mind that fit with in the constraints."*
- *"We determined the people involved, determined the goal, then found solutions, taking into consideration any obstacles."*
- *"Determine the people involved. Determine the problem. Determine any obstacles. Prepare a possible solution"*

Of the 60 participants in the case-based approach who responded to this question, 39 indicated they used a step-by-step process to solve the problems. Some of these responses included:

- *"Find the problem -ask question and become as knowledge[sic] as possible on the subject and relative things. -come up with possible solutions -choose the best solution or solutions."*
- *"Identified the problem, evaluated the possible solutions, then chose the best one."*
- *"Figure out problem--discuss problem with partner--come up with new ideas based on partner's responses--answer problem."*
- *"Read the problems. 2. Came up with solutions on my own. 3. Discussed possibilities with team. 4. Picked the best solution."*

Open-ended questions about the program. Table 7 shows the top three responses by instructional method to the open-ended questions "What did you like best about the program?" and "What would you do to

Table 7.

Responses to attitude survey open-ended questions by instructional method

Question	Instructional Method: Systematic Approach	Instructional Method: Case-Based Approach
What did you like best about the program?	• The realism of the problem scenarios. (n = 24) • The instructional materials. (n = 21) • Working with others. (n = 13)	• Working with others. (n = 22) • The realism of the problem scenarios. (n = 18) • The instructional materials. (n = 11)
What would you do to improve the program?	• Improve the tutorial (i.e. make the assessment scenarios more complex, improve the navigation, more practice, etc.) (n=21) • Allow more time to complete the program. (n = 8). • Use a different medium for communication between team members. (n = 4)	• Improve the tutorial (i.e. make the assessment scenarios more complex, improve the navigation, more practice, etc.) (n=20) • Allow more time to complete the program. (n = 12). • Use a different medium for communication between team members. (n=7),

improve the program?" The data show that the top response for what participants liked best in the systematic approach tutorial was the realism of the assessment scenarios, while the participants in the case-based approach tutorial felt working with others was the best thing about the program. The table also shows that participants in both instructional methods felt changes to the instructional program were the best way to improve the program. These changes included making the assessment scenarios more complex, adding additional practice and feedback, and improving the navigation throughout the tutorial.

Learner-to-Learner Interactions

The last research question dealt with the effect of instructional method and group size on the type and quantity of communications between team members. The data in Table 8 show that there were a total of 3,665 communications between members of the groups. These communications were categorized into one of five possible categories: 1) questions, 2) answers, 3) discussions, 4) encouragement, and 5) off-task. The data show that 17% were "questions", 16% were "answers", 59% were "discussions", 3% were "encouragement" and 5% were "off-task" entries.

A two-way contingency analysis of these data revealed that treatment group and communication category were significantly related, $\chi^2(12, \underline{N}=3665) = 62.8$, $\underline{p} < .001$, *Cramer's V* = 0.08. Follow-up pairwise comparisons were conducted to evaluate the differences among the four treatment groups. The Holm's sequential Bonferroni method (Green, et al., 2000) was used to control for Type I error at the .05 level across all six comparisons. The data in Table 9 shows that three comparisons (system-dyads vs. case-

Table 8.

Participant communications by treatment group and interaction category

Communication Category	System Dyads	System Quads	Case-Based Dyads	Case-Based Quads	Total (%)
	Treatment Group				
Question	163	142	184	118	607 (17%)
Answer	153	129	179	108	569 (16%)
Discussion	558	528	724	370	2180 (59%)
Encouragement	23	26	79	9	137 (3%)
Off-Task	64	45	35	28	172 (5%)
Total (%)	961 (26%)	870 (24%)	1201 (33%)	633 (17%)	3665 (100%)

dyads, system-quads vs.case-dyads, and case-quads vs. case-dyads) of the total number of communications were found to be significant.

Table 9.

Results for the pairwise comparisons using the Holm's sequential Bonferroni method

Comparison	Pearson Chi-Square	p-value	Required p-value for significance	Significance	*Cramér's V*
Case-Dyads vs. Case-Quads	29.9	<.001	.008	*	.13
System-Dyads vs. Case-Dyads	37.9	<.001	.01	*	.13
System-Quads vs. Case-Dyads	19.8	.001	.0125	*	.10
System-Quads vs. Case-Quads	6.9	.14	.0167	NS	.07
System-Dyads vs. Case-Quads	6.0	.197	.025	NS	.06
System-Dyads vs. System-Quads	3.3	.51	.05	NS	.04

Note. * Significant Comparison

Discussion

Performance by Instructional Method and Group Size

The purpose of this study was to investigate the effects of instructional method and computer mediated collaborative group size on learner performance in solving ill-defined problems. Overall, participants performed significantly better on problem two than on problem one. There are two possible reasons for this result. First, it is likely that problem one provided the participants additional practice, which improved their performance on problem two. It is also possible that problem two was easier to solve than problem one. Although both problems dealt with junior officers facing a decision-making dilemma, the characteristics of problem one made could have made it more difficult for the participants to solve.

Separate analyses of the problems indicated that participants who worked in computer-mediated collaborative dyads performed significantly better than did participants who worked in computer-mediated collaborative quads. This finding supports previous research that showed dyads perform better than larger groups (Johnson & Johnson, 1988; Lou, et al., 2001; Collins & Onweugbuzie, 2000). However, in this study dyads performed significantly better only on problem one. The fact dyads interacted more than quads throughout the study may have contribured to this result. Although all participants were able to discuss the problem and related information with others, the results seem to suggest that participants who worked in dyads extracted more

benefit from these learner-to-learner interactions than participants who worked in quads, which positively affected their performance on the more complex task.

The finding that a higher level of collaboration results in better performance is supported by findings from other studies where participants worked in a collaborative learning environment (Chang & Smith, 1991; Flynn & Klein, 2001; Johnson & Chung, 1999; Johnson et al., 1991; Mergendoller et al., 1999; Uribe, et al., in press). The amount of communication between members of dyads when compared to those of quads seems to support the hypothesis that more communication between team members resulted in better performance on problem one. The analysis of the team interactions showed that dyads had a higher number of communications than participants who worked in teams of four. This higher number of communications may have led to the generation of a higher number of possible solutions, and ultimately to better performance on problem one.

The quality of learner-to-learner interaction may have also led to better performance by participants who worked in dyads over those who worked in quads. An informal qualitative analysis of the interaction data conducted by the researcher seemed to indicate that participants who worked in dyads had higher-quality interactions than those who worked in quads. The exchange of ideas and information between members of dyads appeared to probe deeper into the problem, thus generating better possible solutions; whereas the interactions between members of quads seemed to be superficial, lacking depth and insightfulness. The examples below show a sample interaction for a quad and a dyad when solving problem scenario one. These examples are representative of the interactions observed during the study.

Quad example:

Student 1 > we are doing #1 right?
Student 2 > yeah
Student 3 > right
Student 4 > si
Student 1 > good, i [sic] am ready
Student 4 > me too
Student 2 > let's do it then
Student 2 > what's our solution?
Student 2 > take away the other flight and remind the flight that we have to get on board?
Student 3 > Bust there [sic] chops.
Student 1 > make them pack,
Student 1 > that too,
Student 4 > make them pack
Student 1 > get rid of the other guys

Dyad Example:

Student 1 > ok, I'm starting on the first one
Student 2 > ME TOO
Student 1 > what do you think?
Student 2 > i [sic] think that b-flight needs to get out of there
Student 2 > but, in the scenario, we're only an [sic] lt and the b-flight com is a captain
Student 2 > so that could pose a problem
Student 1 > good point
Student 1 > but I think the mission is more important so we should have them pack and then they can chat with bflight
Student 2 > i agree
Student 1 > is that our solution then?
Student 2 > well, how do we get them to pack
Student 1 > we order them to
Student 2 > right, but they will still be distracted by b flight
Student 2 > so, i think we should order our troops to pack (direct order)
Student 1 > we need an incentive to pack
Student 2 > and make it very clear to the captain that we want his flight out of there until we're done
Student 1 > ok

While group size had a significant effect on performance, instructional method did not. There are two possible reasons for this result. First, the participants who worked through the case-based approach appeared to have acquired a heuristic that they were able to apply to the problem scenarios. The results show that participants in both instructional methods used a process to solve the problems. Most participants in the systematic approach group indicated they used the 4-step process they learned in the tutorial, while about 65% of the participants in the case-based approach used a three-step heuristic similar to the one learned by the participants in the systematic approach. This seems to support the notion that when learners are faced with a problem situation, they develop a mental model that can then be applied to similar situations (VanMerrienboer, et al., 2002) The fact that both treatment groups applied a step-by-step approach to solve the problems may have equalized their performance on the assessment scenarios.

Another reason for the non-significant finding may have been that the time limitations imposed on the study weakened the instructional programs. The survey results show that students felt they could have benefited from additional practice, additional examples and, perhaps most importantly, additional time. It is important to point out that the original instructional programs were shortened after two formative evaluations showed both programs would take longer than the time available for this study.

These reductions to the instructional programs may also have led to the overall poor performance by both treatment groups on the problem scenarios. Participants spent an overall average of 31.3 minutes on the tutorial, 9.3 minutes on problem one and 9.5

minutes on problem two. Although poor performance on problem-solving tasks has been evident in similar studies (Flynn & Klein, 2001; Uribe, et al, in press), the short amount of time spent on instruction and a reduced set of practice scenarios may have contributed to lower performance scores in this study.

Time Spent on Instruction

The results for time spent on instruction revealed that participants who used the case-based tutorial spent significantly more time on instruction than participants who used the systematic approach. Case-based participants may have spent more time on the learning task because of key differences in the two instructional programs. In the systematic approach participants were taught each step of a problem-solving process, and then were directed to use each step in a practice scenario. Conversely, the case-based approach program was designed to allow the participants more opportunity to reflect on the problem scenarios and to formulate alternative paths to a best possible solution. This difference in the teaching/learning approach may have had an impact on the time spent on the tutorial.

Another explanation may be that the participants in the case-based approach spent more time on instruction because of the increased cognitive load of developing a heuristic or mental model that could be applied to other similar problems (Van Merrienboer, 2002). Participants who learned the systematic approach learned a heuristic directly from the instruction, and therefore did not have the additional mental burden of formulating a step-by-step approach.

Time spent solving problems

In contrast to the results for time spent on instruction, participants who used the systematic approach spent more time solving the problems than did participants in the case-based approach. Participants who used the systematic approach may have spent more time methodically applying the steps of the problem-solving process to solve the scenarios. Although participants in the case-based approach also used a heuristic to solve the problems, most appeared to have used a two or three-step process rather than the full four-step process used by the systematic-approach participants. This may have contributed to the difference in the time spent solving problems.

However, the results for time spent solving problem two were different than the results for problem one. In addition to the significant difference between participants in the systematic approach and the case-based approach for time spent on the problem, problem two exhibited a significant interaction between instructional method and group size. The data show that quads who used the systematic approach spent significantly more time on the problem than did quads using the case-based approach. However, there was no significant difference between dyads who used the systematic approach and those who used the case-based approach. Quads who used the systematic approach may have spent more time on the problem because applying a more structured process to solve the problems required additional coordination than applying a more open-ended case-based approach.

In addition to the higher degree of coordination required to apply a systematic approach to solve problems, confusion arising from synchronous computer-mediated

communication in large groups might have also contributed to these results. An informal qualitative analysis of the data indicates that participants who worked in quads experienced some confusion during the communication process. The larger number of team members in the quads might have been a factor in creating a confusing learning environment. This is in line with other research that has shown larger groups may require a moderator to be effective (McIsaac and Ralston, 1996). The attempt to apply a more structured approach in this somewhat disorganized communication environment may have led quads to spend more time solving problem two than participants working in dyads. The example below shows a typical exchange between four members of a quad where the conversation seems somewhat disjointed:

Student 1 > hey guys
Student 2 > yeah
Student 2 > sounds good
Student 1 > I just read that thingy
Student 3 > what thingy
Student 2 > are we "ready to answer the questions"?
Student 1> sure
Student 4 > yes
Student 3 > you guys done with that
Student 2 > with what?
Student 3 > with those answers
Student 2 > not yet
Student 4 > yes

The data for number of participants who completed bonus problems also appears to indicate quads may not be an ideal grouping when working on complex problems. The results show that participants who worked in quads in both instructional methods were less likely to complete both bonus problems than were participants who worked in dyads.

Participant attitudes

In general, participants indicated a preference for working collaboratively. The data specifically show that a majority of participants prefer to work with one or two partners when solving ill-defined problems. Other research has also shown a preference by learners to work in collaborative environments (Flynn & Klein, 2001; Johnson et al., 1991; Lou et al., 2001, Uribe, et al., in press). However, collaborating on-line was rated lowest (1.68 out 3.0) by the participants indicating that learners did not necessarily enjoy collaborating using a text-based system. This supports other research, which found that participants did not enjoy on-line collaboration due to the difficulties of communicating via a computer (Uribe, et al., in press).

However, participant attitudes toward collaborating on-line were not constant across the instructional methods. Participants who worked in quads and used the systematic approach liked collaborating on-line significantly more than dyads who used the systematic approach; whereas, there was not a significant difference between dyads and quads who used the case-based approach. Since dyads appear to have attempted more in-depth discussions of the problems, they may have felt more frustrated attempting to collaborate in a more structured environment. However, participants who worked in quads did not experience the same level of frustration using the systematic approach because their communications remained at a superficial level.

The survey results also show that the participants enjoyed the Internet-based learning materials. The instructional materials were listed as one of the top three things participants liked best in both instructional methods. This finding supports other research

where student attitudes toward web-based instruction have been found to be positive (Adelskold, 1999; McIsaac & Ralston, 1996; Savenye, 2001; Uribe, et al., in press). The realism of the problem scenarios, cited by a large number of participants as something they liked best about the entire program, could have also contributed to participant enjoyment of the learning materials.

The attitude survey also attempted to gauge the learner perceptions on the applicability of the problem-solving skills learned to other settings. The results indicated that most participants agreed that what they had learned in this study would transfer to other situations. This is in line with similar studies that have found a positive attitude towards transfer of problem-solving skills to similar situations (Uribe, et al., in press). Participants felt they would use this process in their professional lives because the problems they faced in the study were directly related to their future career as Air Force officers. Additional evidence that supports this hypothesis is that the highest rated survey item dealt with the realism and applicability of the scenarios to an Air Force career.

Learner-to-Learner Interactions

The analysis of the learner-to-learner interactions showed that the number of communications in each category varied significantly as a function of treatment group. Results revealed that participants who worked in case-based dyads had significantly more communications than the other treatment groups. These data also suggested that dyads collaborated more than quads in both the systematic and case-based approaches. This additional collaboration might have been a factor in dyads performing better than quads on problem one. This finding is in line with the results found by Uribe, et al. (in press),

where increased collaboration directly contributed to better performance when solving ill-defined problems.

The majority of communications that took place between team members were related to the task. These results also show that over half of the communications were categorized as "discussion," indicating that the participants in all treatment groups were actively engaged in discussion of the problem or related information. This finding supports other research where a collaborative learning environment produced a high percentage of on-task interactions (Flynn & Klein, 2001; Klein & Doran, 1999; Sherman & Klein, 1995; Uribe, et al., in press).

Implications

This study has clear implications for the design and delivery of distance learning. The study indicates that grouping learners into dyads instead of quads maybe a better strategy when learning and applying problem-solving skills in a web-based environment. When time-on-task data and number of problems completed is considered in conjunction with performance and group interaction data, findings seem to suggest that dyads are a more efficient grouping than quads. The results show that dyads communicated more, spent less time-on-task, completed more problems and performed better than quads on one of the problem scenarios.

The study also suggests that a computer-mediated environment is conducive to collaboration. The high percentage of on-task interactions indicates that computer-mediated collaborative learning should be considered when high-interactivity and exchange of ideas is a major component of a distance learning program. But while

learners appear to enjoy working together when solving complex problems, instructional designers and instructors should keep in mind that collaborating using text-based communications appears to have some drawbacks. Additional time should be factored into any program to allow the learner ample time for communication.

The findings of this study also indicate that the systematic approach and the case-based approach may be equally effective for solving ill-defined problems. Some of the evidence indicates that the case-based method may be a better approach if a goal of the learning program is for the learner to develop his or her own rules-of-thumb or heuristics for problem solving. But regardless of method used, the findings clearly suggest that learners enjoy scenarios that closely match the "real world." If possible, problem scenarios representative of the learner's future profession should be used when teaching how to solve ill-defined problems.

Further Research

The results of this study suggest other areas that could be addressed by additional research. The likely interdependence of the dependent measures in a collaborative environment should be explored. Alternative statistical analysis techniques, such as the Hierarchical Linear Model, could be used to avoid the potential pitfalls of violating the independence of scores assumption of ANOVA.

Different computer-mediated collaborative group sizes should be explored to determine an optimal size. Although this study indicates that dyads may be more effective than quads, additional research should investigate alternative group sizes. This study seems to indicate that as group size increases, the efficiency of the group decreases.

Research into other groupings could yield data that could be used to confirm this finding and to develop a prediction model for the effect of group size on performance when solving ill-defined problems.

The instructional methods used to teach problem solving could also benefit from additional research. Variations of the systematic and case-based strategies for problem solving should be explored to determine the best approach for specific problem-solving tasks. It would be useful for instructional designers and practitioners to know if a particular approach is better suited for certain types of tasks in a computer-mediated collaborative environment. For example, the ill-defined problems identified by Jonassen (2000) such as decision-making, strategic performance, case analysis and design problems could be examined. Also, specific characteristics of each approach, such as number of steps in a systematic approach or types of thought-provoking questions in the case-based approach, could be manipulated to determine their effects on performance. Research on the different facets of computer-mediated collaboration should help us identify the most effective instructional practices to effectively promote the learning of problem-solving skills in a web-based environment.

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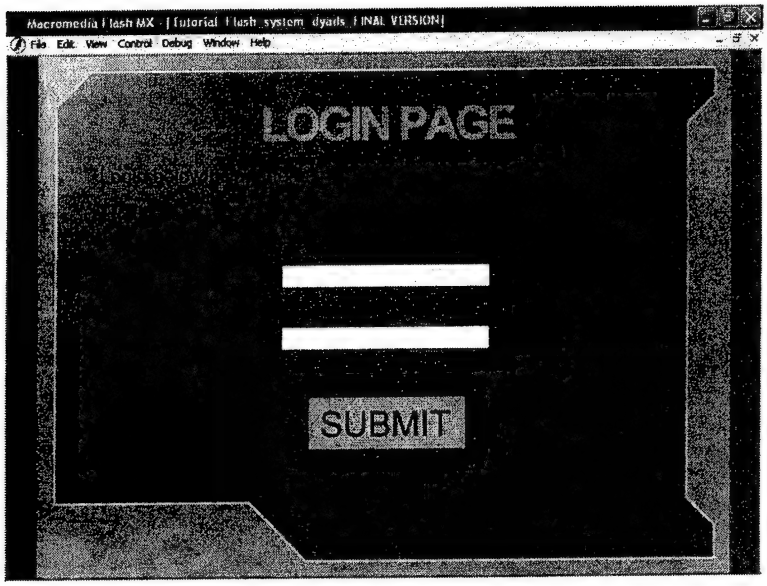
APPENDIX A

INSTRUCTIONAL PROGRAM – SYSTEMATIC APPROACH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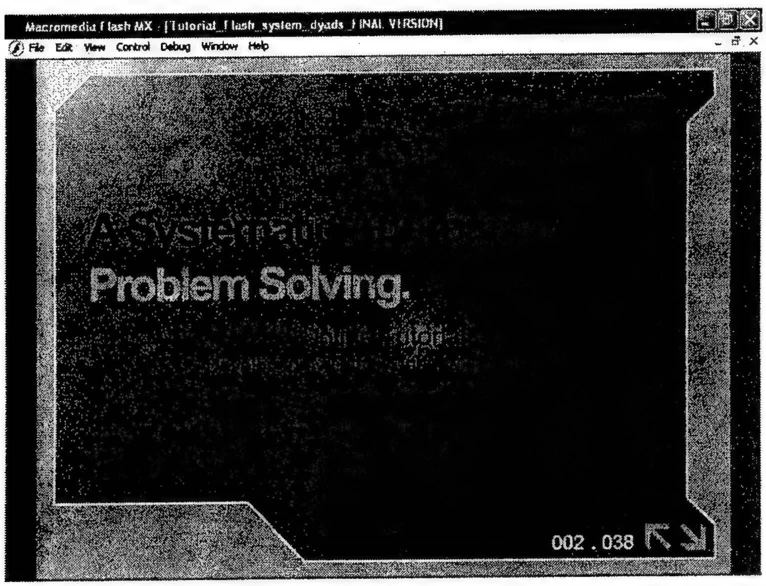
LOGIN PAGE
SUBMIT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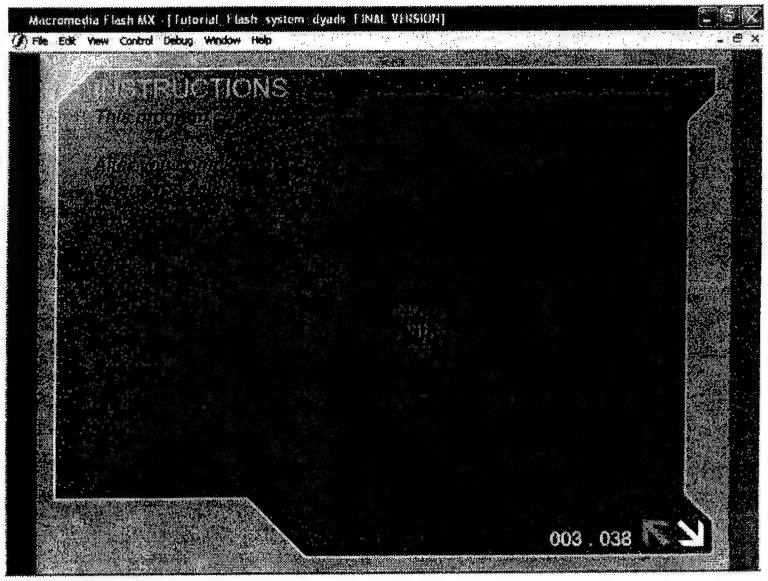
Problem Solving.
002 . 038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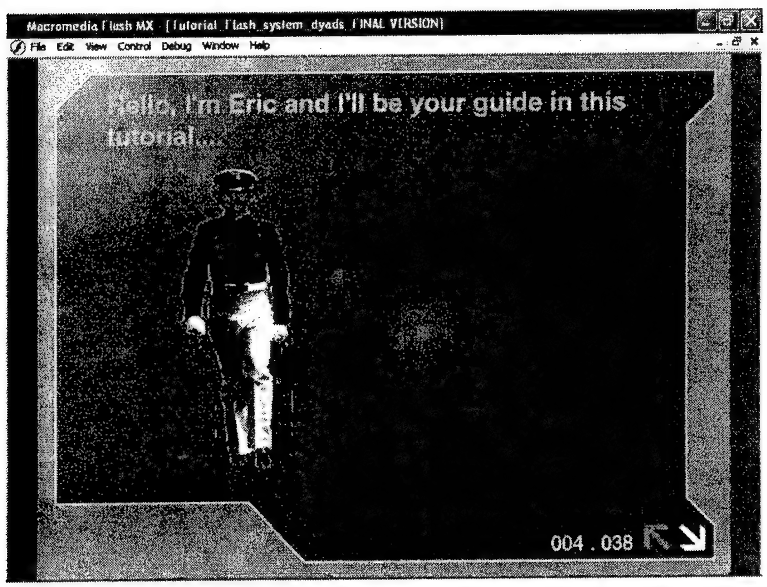
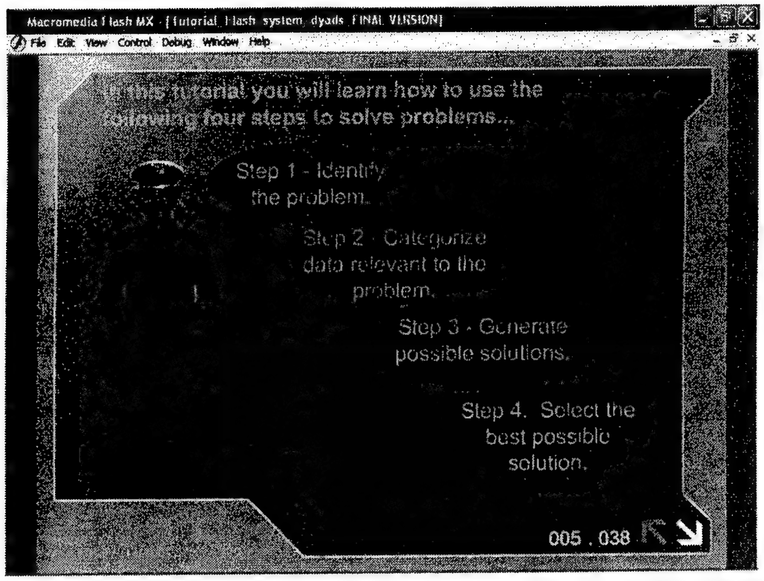
File Edit View Control Debug Window Help
INSTRUCTIONS
003 . 038


Macromedia Flash MX - [Tutorial_Flash_system_dyads_FINAL VERSION]
File Edit View Control Debug Window Help
Hello, I'm Eric and I'll be your guide in this tutorial...
004 . 038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In this tutorial you will learn how to use the following four steps to solve problems...
Step 1 - Identify the problem.
Step 2 - Categorize data relevant to the problem.
Step 3 - Generate possible solutions.
Step 4. Select the best possible solution.
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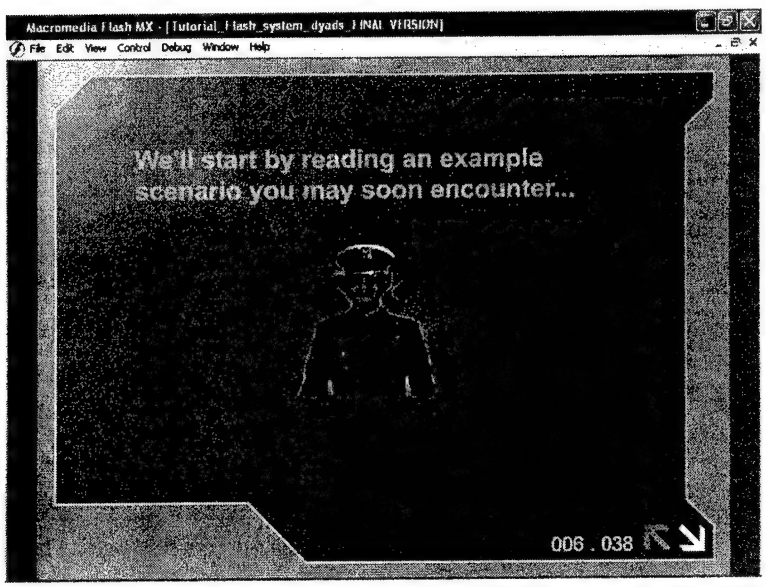
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We'll start by reading an example scenario you may soon encounter...
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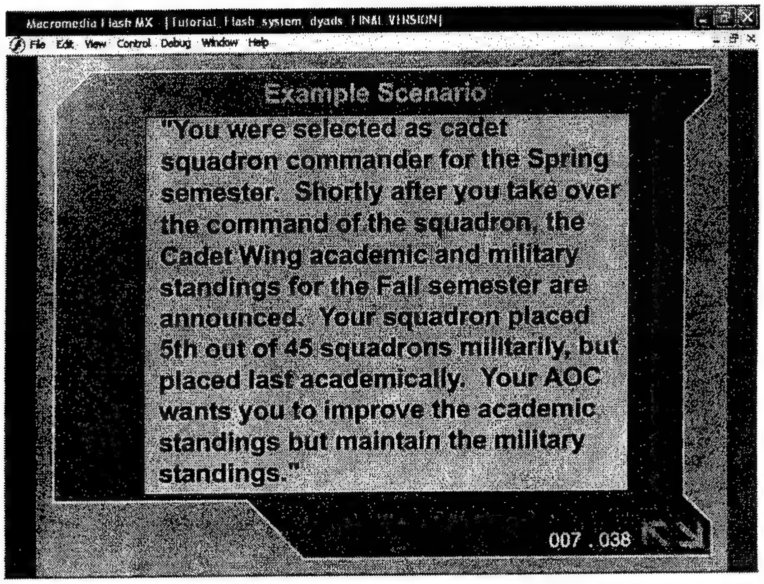
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Example Scenario
"You were selected as cadet squadron commander for the Spring semester. Shortly after you take over the command of the squadron, the Cadet Wing academic and military standings for the Fall semester are announced. Your squadron placed 5th out of 45 squadrons militarily, but placed last academically. Your AOC wants you to improve the academic standings but maintain the military standings."
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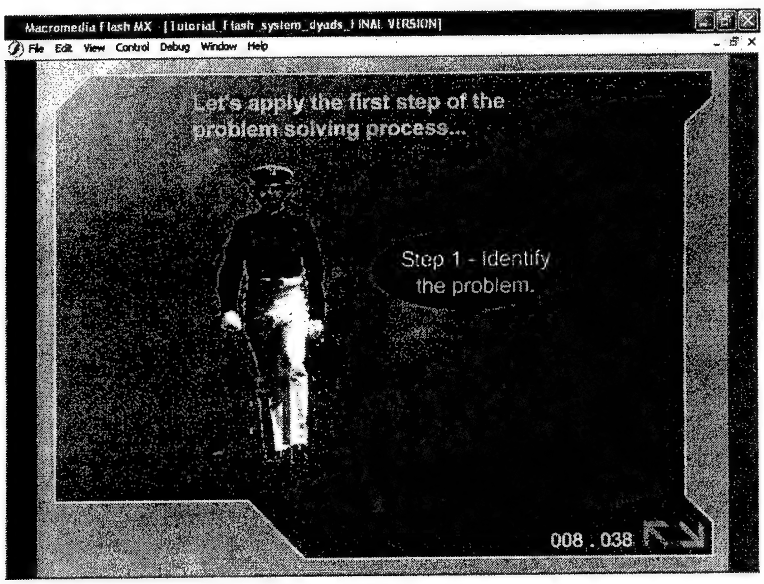
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Let's apply the first step of the problem solving process...
Step 1 - identify the problem.
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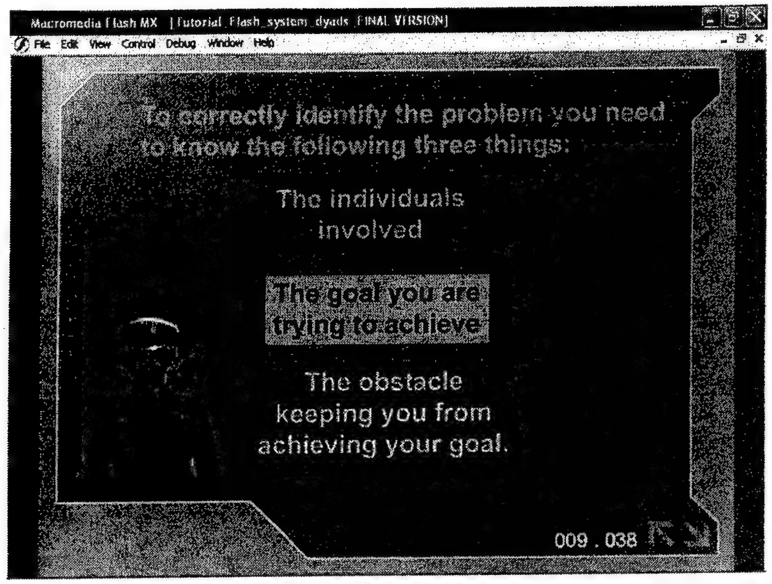
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To correctly identify the problem you need to know the following three things:
The individuals involved
The goal you are trying to achieve
The obstacle keeping you from achieving your goal.
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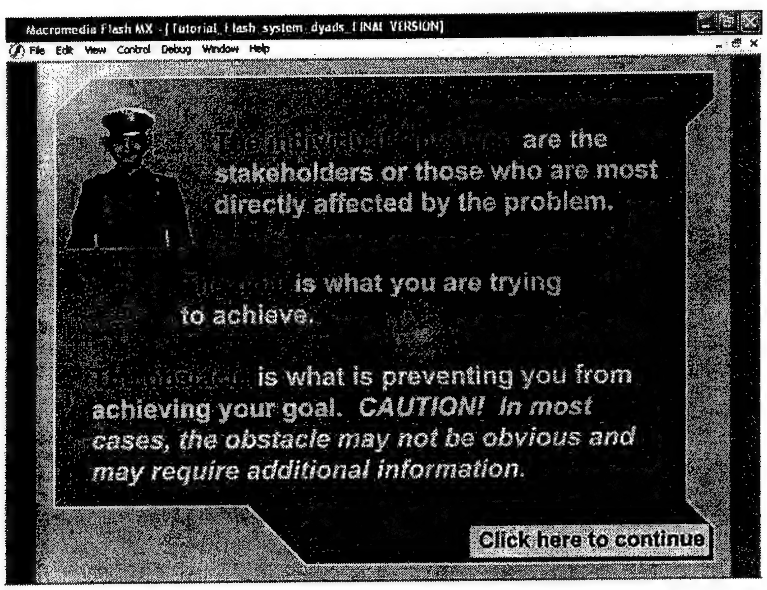
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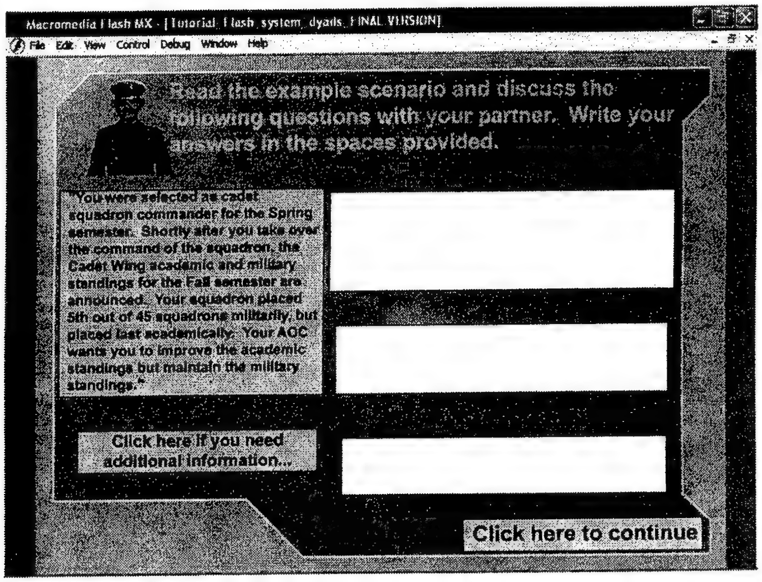
are the stakeholders or those who are most directly affected by the problem.
is what you are trying to achieve.
is what is preventing you from achieving your goal. CAUTION! In most cases, the obstacle may not be obvious and may require additional information.
Click here to continue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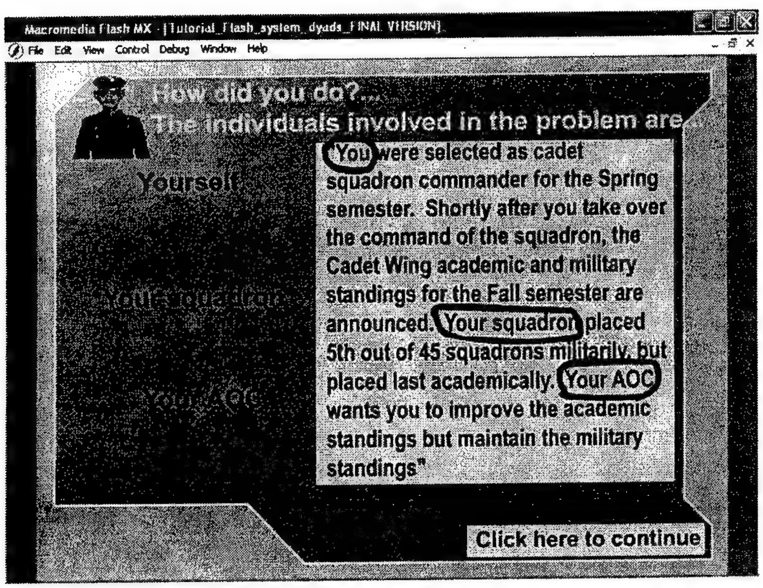
Read the example scenario and discuss the following questions with your partner. Write your answers in the spaces provided.
"You were selected as cadet squadron commander for the Spring semester. Shortly after you take over the command of the squadron, the Cadet Wing academic and military standings for the Fall semester are announced. Your squadron placed 5th out of 45 squadrons militarily, but placed last academically. Your AOC wants you to improve the academic standings but maintain the military standings."
Click here if you need additional information...
Click here to continue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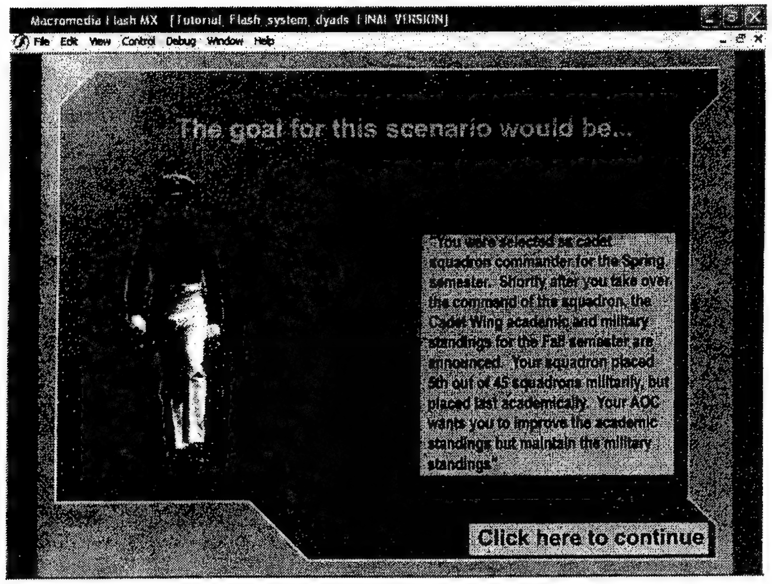
How did you do?...
The individuals involved in the problem are...
Yourself
Your squadron
Your AOC
You were selected as cadet squadron commander for the Spring semester. Shortly after you take over the command of the squadron, the Cadet Wing academic and military standings for the Fall semester are announced. Your squadron placed 5th out of 45 squadrons militarily, but placed last academically. Your AOC wants you to improve the academic standings but maintain the military standings"
Click here to continue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The goal for this scenario would be...
"You were selected as cadet squadron commander for the Spring semester. Shortly after you take over the command of the squadron, the Cadet Wing academic and military standings for the Fall semester are announced. Your squadron placed 5th out of 45 squadrons militarily, but placed last academically. Your AOC wants you to improve the academic standings but maintain the military standings"
Click here to continue


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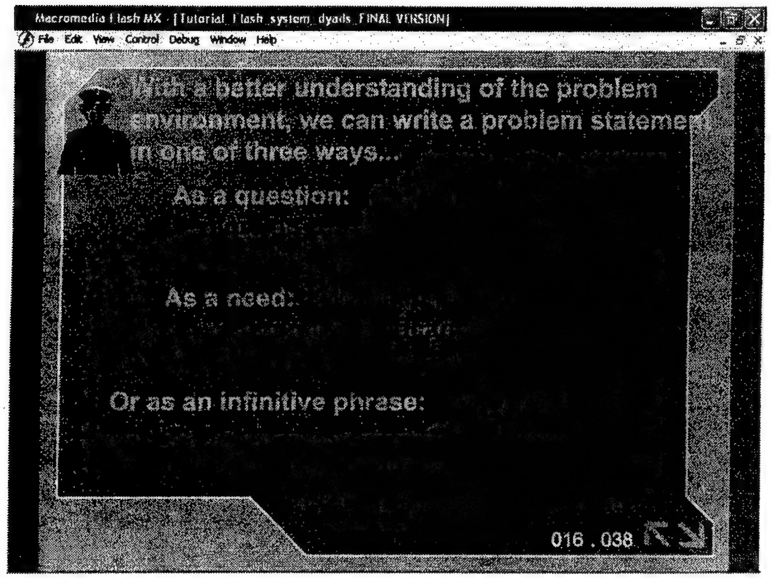
For the obstacle, you probably came up with an asnwer similar to mine...
The obstacle is:
Click here to continue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With a better understanding of the problem environment, we can write a problem statement in one of three ways...
As a question:
As a need:
Or as an infinitive phrase:
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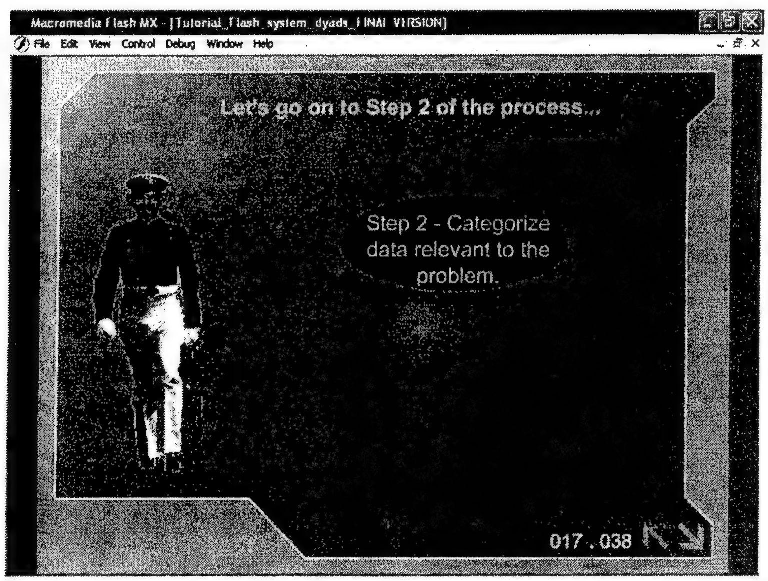
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Let's go on to Step 2 of the process...
Step 2 - Categorize data relevant to the problem.
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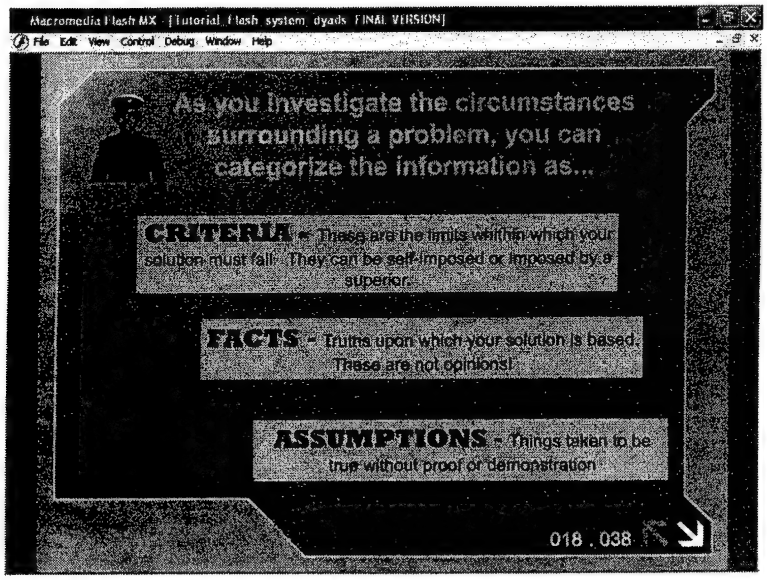
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As you investigate the circumstances surrounding a problem, you can categorize the information as...
CRITERIA - These are the limits within which your solution must fall. They can be self-imposed or imposed by a superior.
FACTS - Truths upon which your solution is based. These are not opinions!
ASSUMPTIONS - Things taken to be true without proof or demonstration
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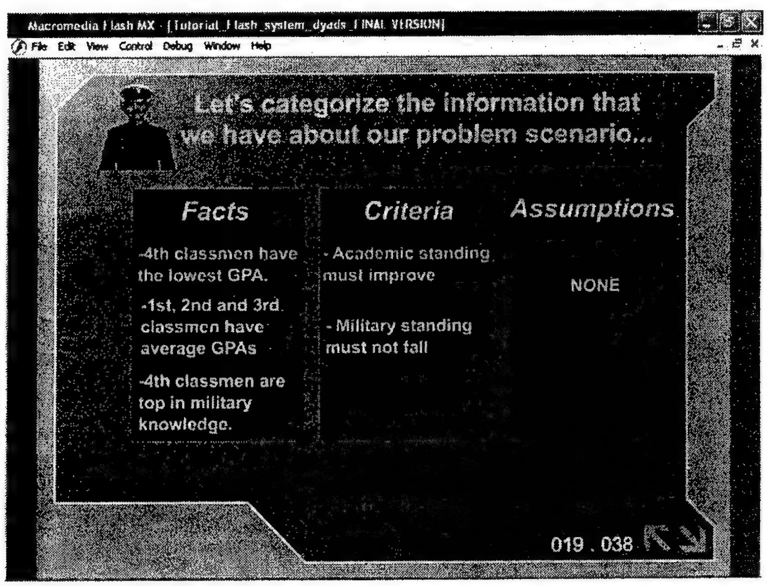
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Let's categorize the information that we have about our problem scenario...
Facts
-4th classmen have the lowest GPA.
-1st, 2nd and 3rd classmen have average GPAs
-4th classmen are top in military knowledge.
Criteria
- Academic standing must improve
- Military standing must not fall
Assumptions
NONE
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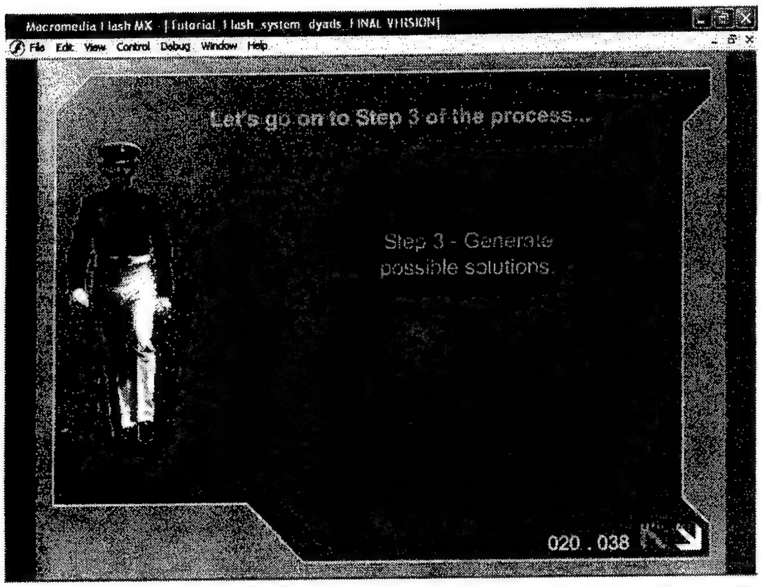
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Let's go on to Step 3 of the process...
Step 3 - Generate possible solutions.
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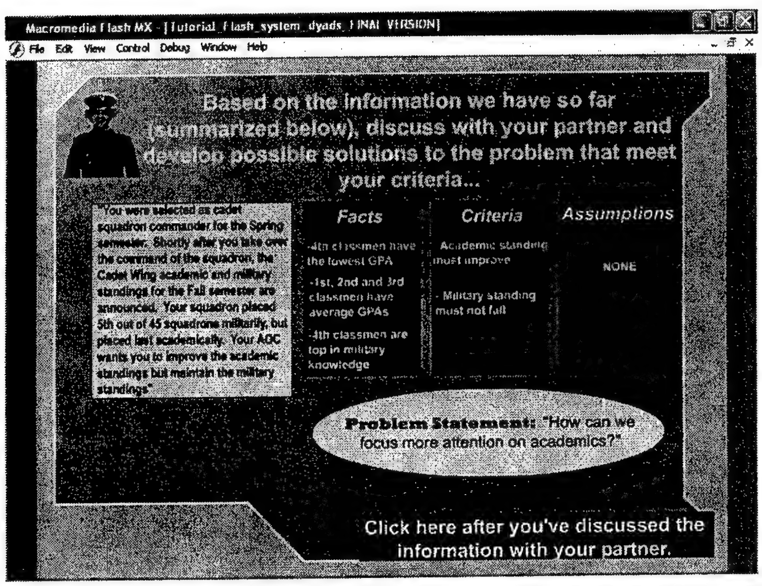
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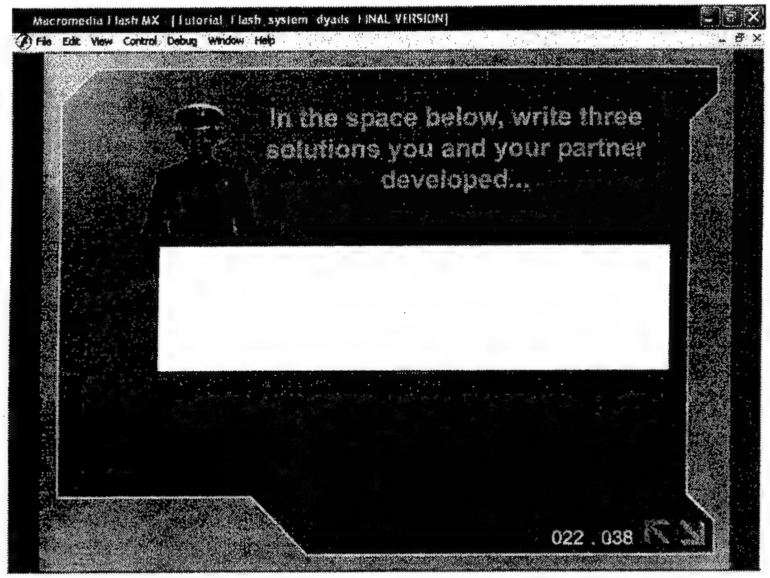
File Edit View Control Debug Window Help
Based on the information we have so far (summarized below), discuss with your partner and develop possible solutions to the problem that meet your criteria...
"You were selected as cadet squadron commander for the Spring semester. Shortly after you take over the command of the squadron, the Cadet Wing academic and military standings for the Fall semester are announced. Your squadron placed 5th out of 45 squadrons militarily, but placed last academically. Your AOC wants you to improve the academic standings but maintain the military standings"
Facts
-4th classmen have the lowest GPA
-1st, 2nd and 3rd classmen have average GPAs
-4th classmen are top in military knowledge
Criteria
- Academic standing must improve
- Military standing must not fall
Assumptions
NONE
Problem Statement: "How can we focus more attention on academics?"
Click here after you've discussed the information with your partner.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In the space below, write three solutions you and your partner developed...
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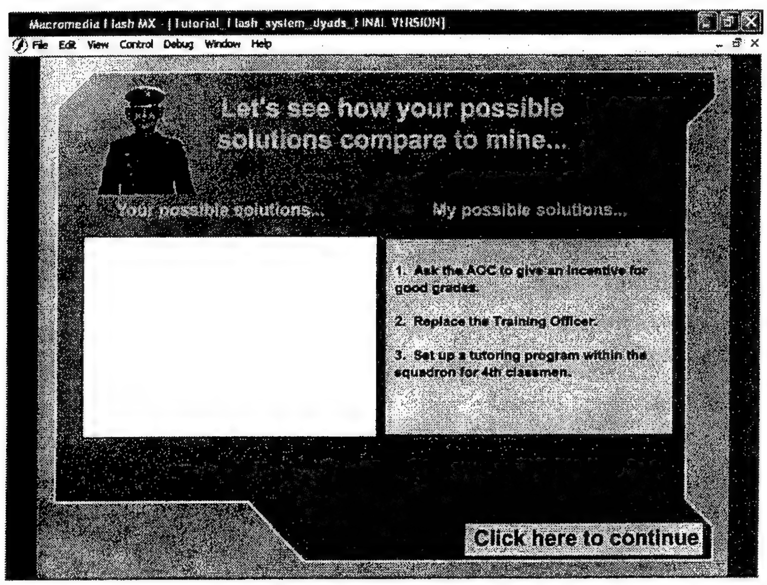
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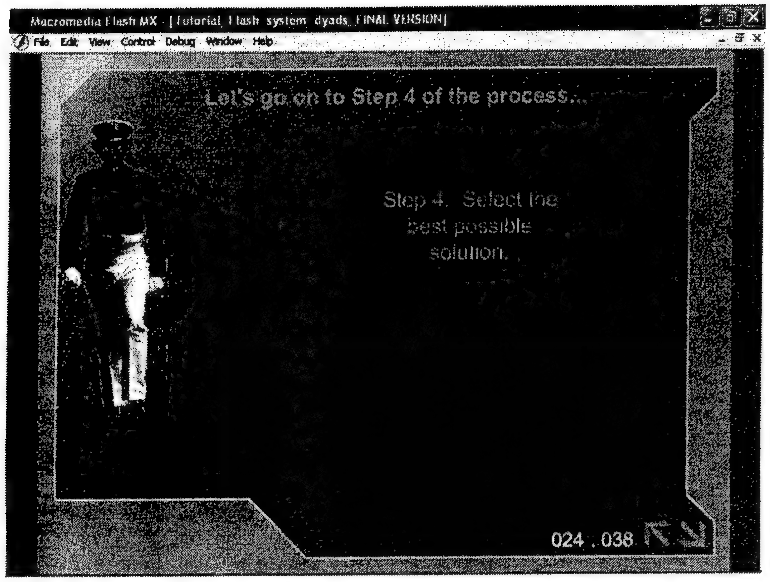
Let's see how your possible solutions compare to mine...
Your possible solutions...
My possible solutions...
1. Ask the AOC to give an incentive for good grades.
2. Replace the Training Officer.
3. Set up a tutoring program within the squadron for 4th classmen.
Click here to continue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Let's go on to Step 4 of the process...
Step 4. Select the best possible solution.
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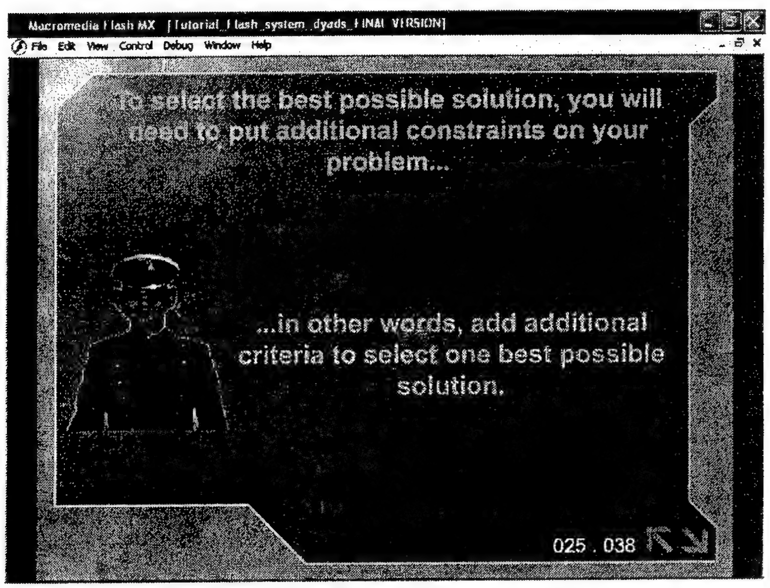
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To select the best possible solution, you will need to put additional constraints on your problem...
...in other words, add additional criteria to select one best possible solution.
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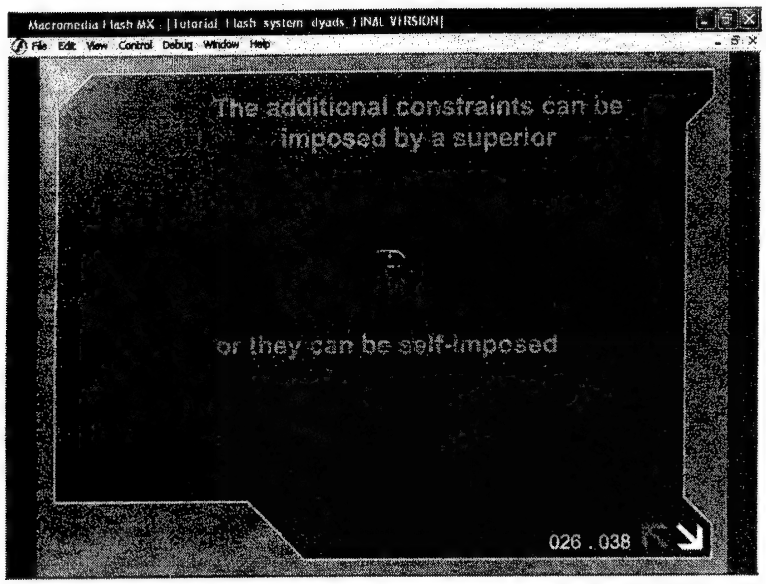
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The additional constraints can be imposed by a superior
or they can be self-imposed
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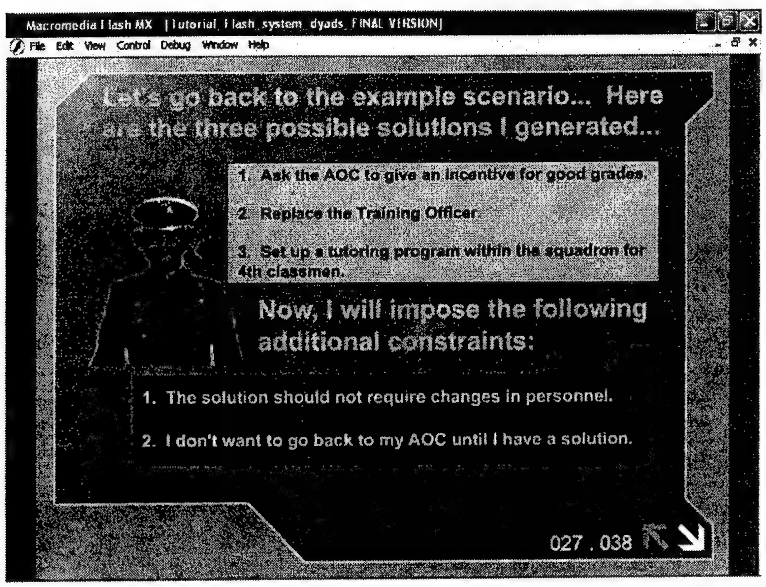
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Let's go back to the example scenario... Here are the three possible solutions I generated...
1. Ask the AOC to give an incentive for good grades.
2. Replace the Training Officer.
3. Set up a tutoring program within the squadron for 4th classmen.
Now, I will impose the following additional constraints:
1. The solution should not require changes in personnel.
2. I don't want to go back to my AOC until I have a solution.
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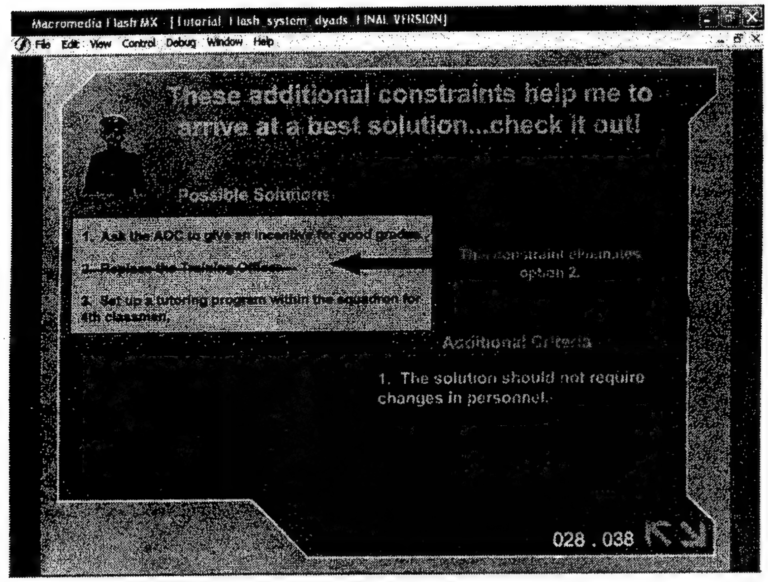

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These additional constraints help me to arrive at a best solution...check it out!
Possible Solutions
1. Ask the AOC to give an incentive for good grades.
~~2. Replace the Training Officer.~~
3. Set up a tutoring program within the squadron for 4th classmen.
This constraint eliminates option 2.
Additional Criteria
1. The solution should not require changes in personnel.
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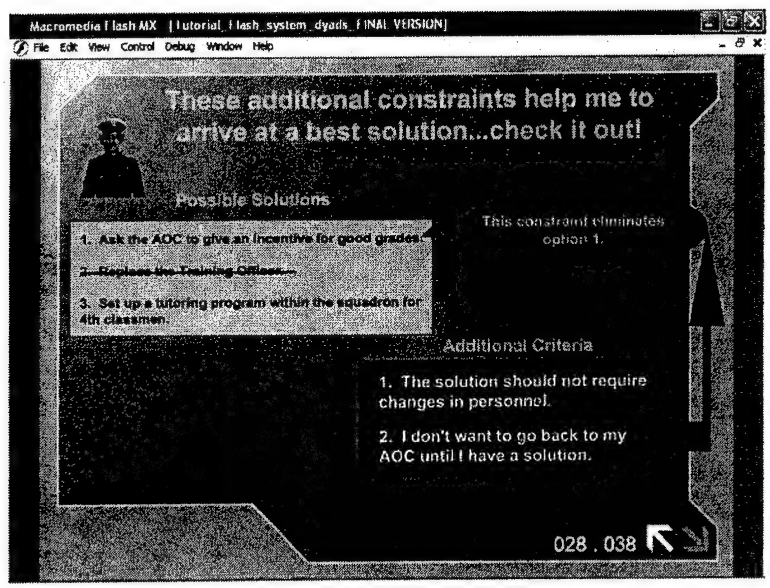

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These additional constraints help me to arrive at a best solution...check it out!
Possible Solutions
1. Ask the AOC to give an incentive for good grades.
~~2. Replace the Training Officer.~~
3. Set up a tutoring program within the squadron for 4th classmen.
This constraint eliminates option 1.
Additional Criteria
1. The solution should not require changes in personnel.
2. I don't want to go back to my AOC until I have a solution.
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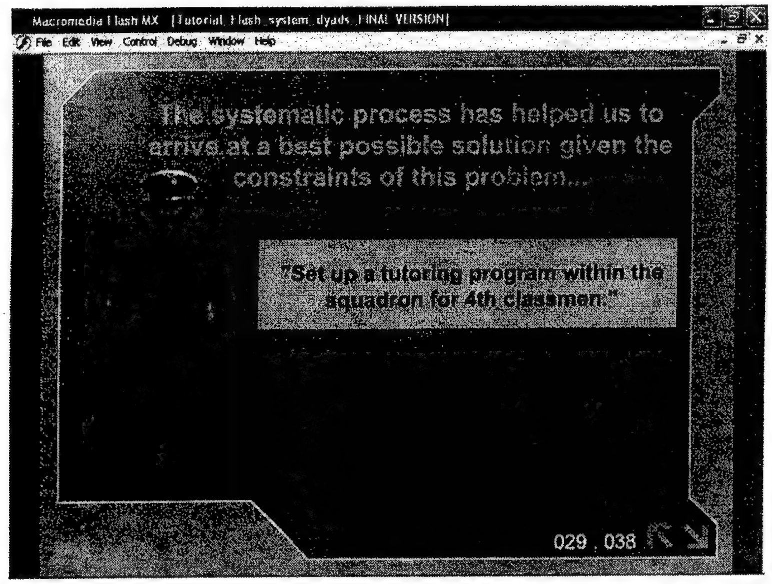
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The systematic process has helped us to arrive at a best possible solution given the constraints of this problem...
"Set up a tutoring program within the squadron for 4th classmen."
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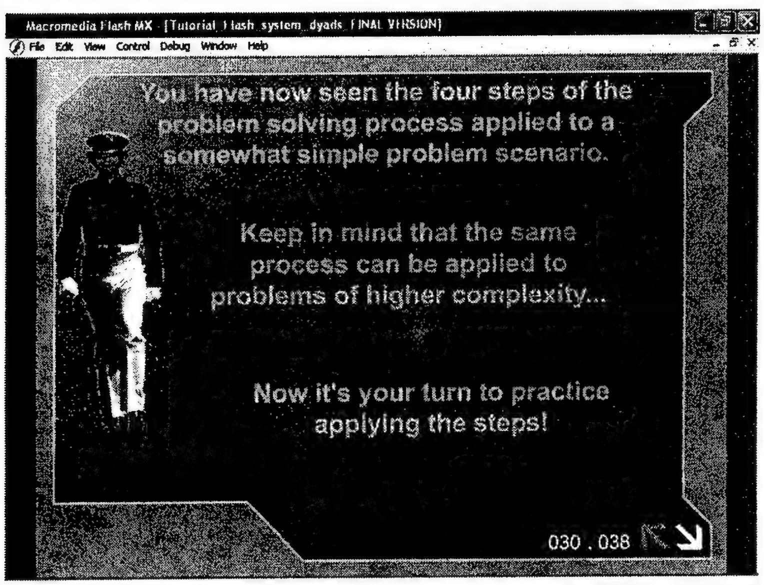
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You have now seen the four steps of the problem solving process applied to a somewhat simple problem scenario.
Keep in mind that the same process can be applied to problems of higher complexity...
Now it's your turn to practice applying the steps!
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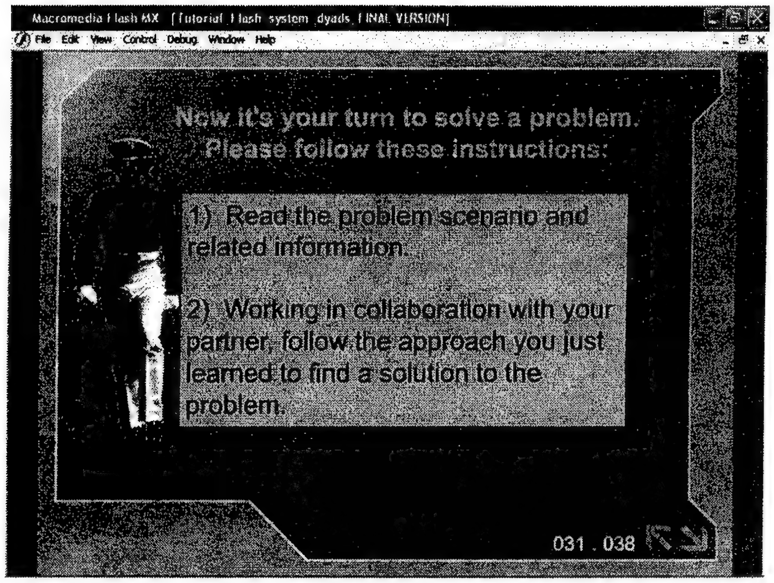
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Now it's your turn to solve a problem.
Please follow these instructions:
1) Read the problem scenario and related information.
2) Working in collaboration with your partner, follow the approach you just learned to find a solution to the problem.
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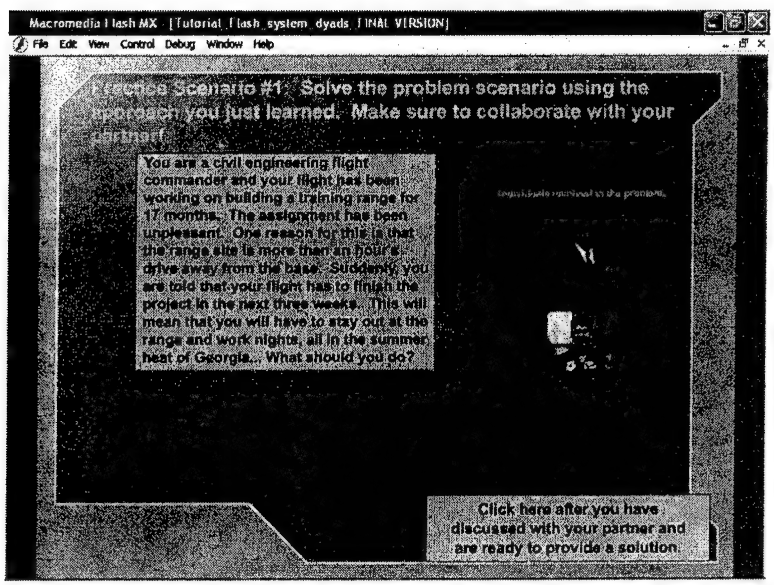
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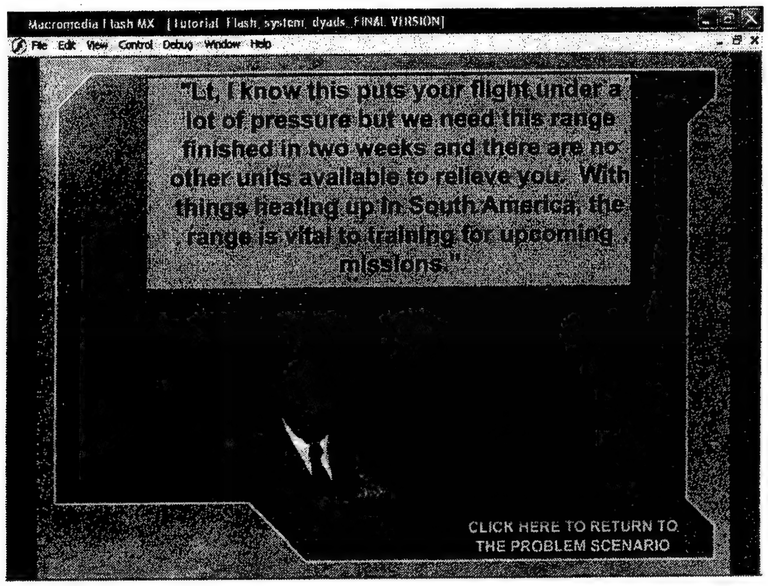
Scenario #1: Solve the problem scenario using the
you just learned. Make sure to collaborate with your
You are a civil engineering flight commander and your flight has been working on building a training range for 17 months. The assignment has been unpleasant. One reason for this is that the range site is more than an hour's drive away from the base. Suddenly you are told that your flight has to finish the project in the next three weeks. This will mean that you will have to stay out at the range and work nights, all in the summer heat of Georgia... What should you do?
Click here after you have discussed with your partner and are ready to provide a solution.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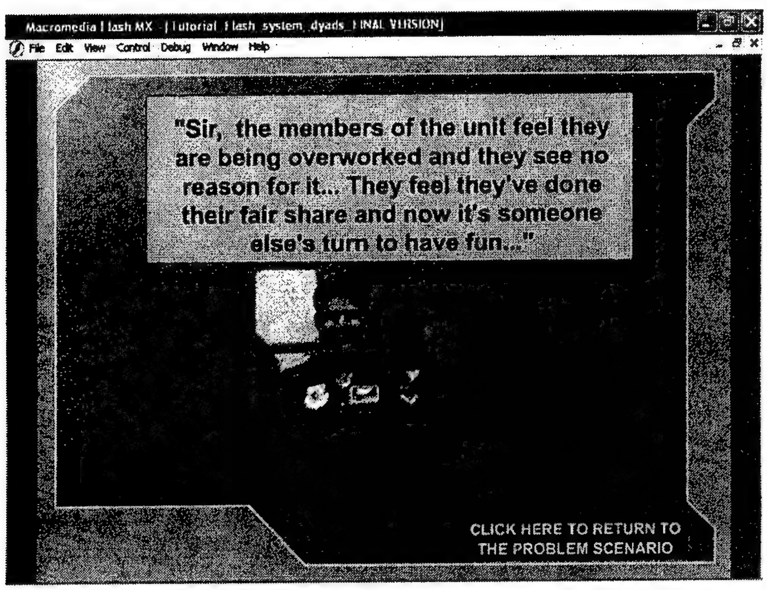
"Lt, I know this puts your flight under a lot of pressure but we need this range finished in two weeks and there are no other units available to relieve you. With things heating up in South America, the range is vital to training for upcoming missions."
CLICK HERE TO RETURN TO THE PROBLEM SCENARIO


Macromedia Flash MX - [Tutorial_Flash_system_dyads_FINAL VERSION]
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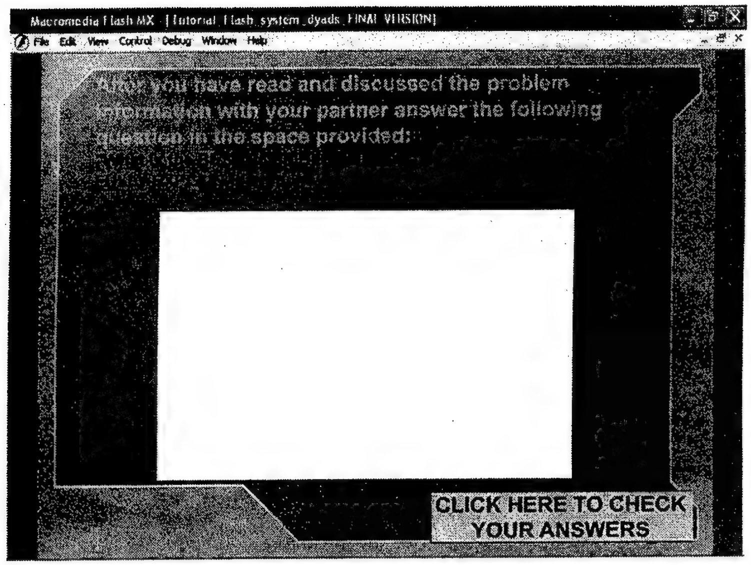
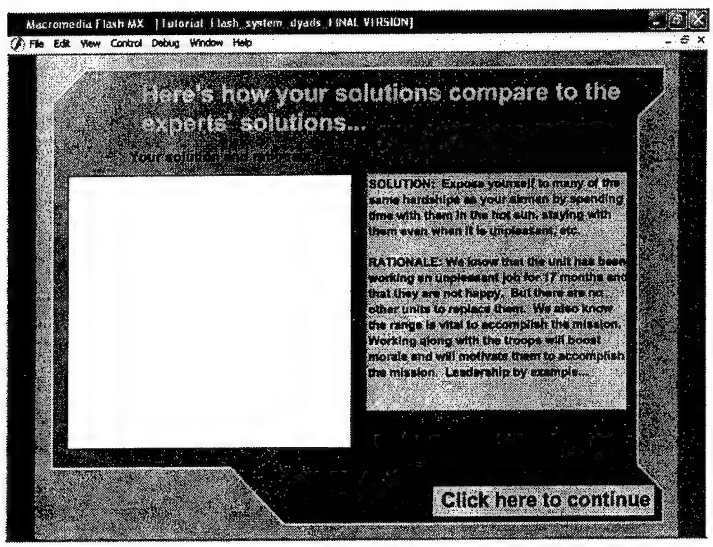
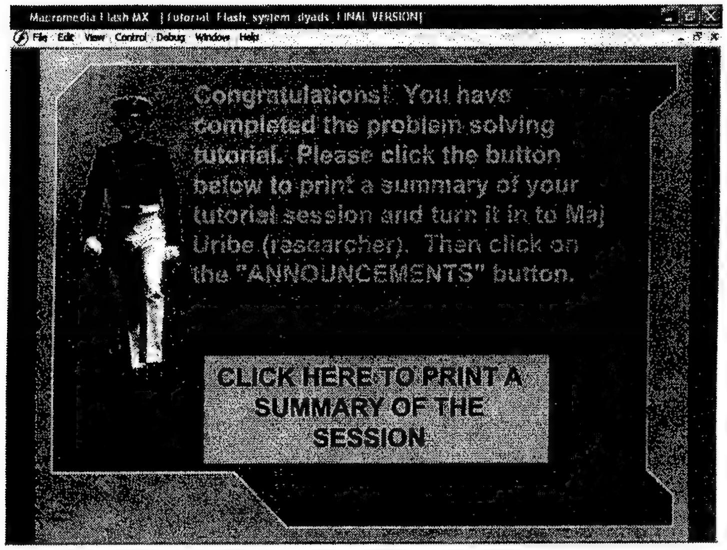
"Sir, the members of the unit feel they are being overworked and they see no reason for it... They feel they've done their fair share and now it's someone else's turn to have fun..."
CLICK HERE TO RETURN TO THE PROBLEM SCENARIO


After you have read and discussed the problem information with your partner answer the following question in the space provided:
CLICK HERE TO CHECK YOUR ANSWERS


Here's how your solutions compare to the experts' solutions...
SOLUTION: Expose yourself to many of the same hardships as your airmen by spending time with them in the hot sun, staying with them even when it is unpleasant, etc.
RATIONALE: We know that the unit has been working an unpleasant job for 17 months and that they are not happy. But there are no other units to replace them. We also know the range is vital to accomplish the mission. Working along with the troops will boost morale and will motivate them to accomplish the mission. Leadership by example...
Click here to continue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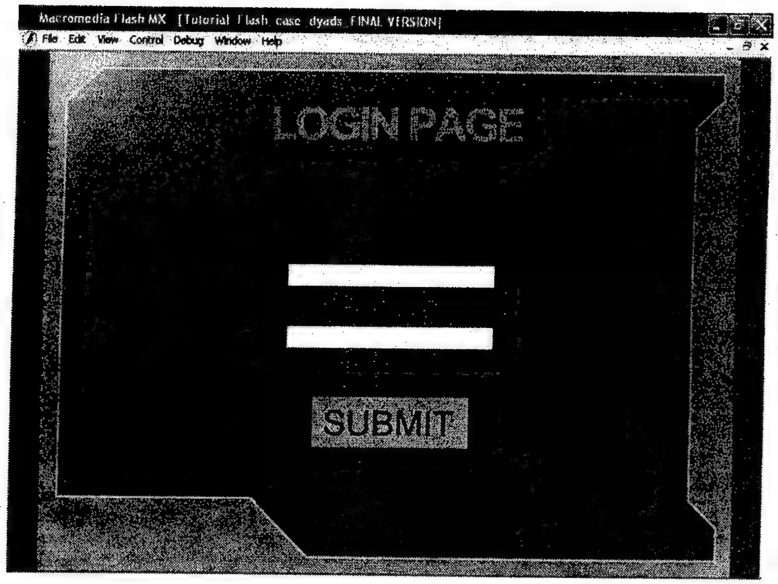
File Edit View Control Debug Window Help
Congratulations! You have completed the problem solving tutorial. Please click the button below to print a summary of your tutorial session and turn it in to Maj Uribe (researcher). Then click on the "ANNOUNCEMENTS" button.
CLICK HERE TO PRINT A SUMMARY OF THE SESSION

APPENDIX B

INSTRUCTIONAL PROGRAM – CASE-BASED APPROACH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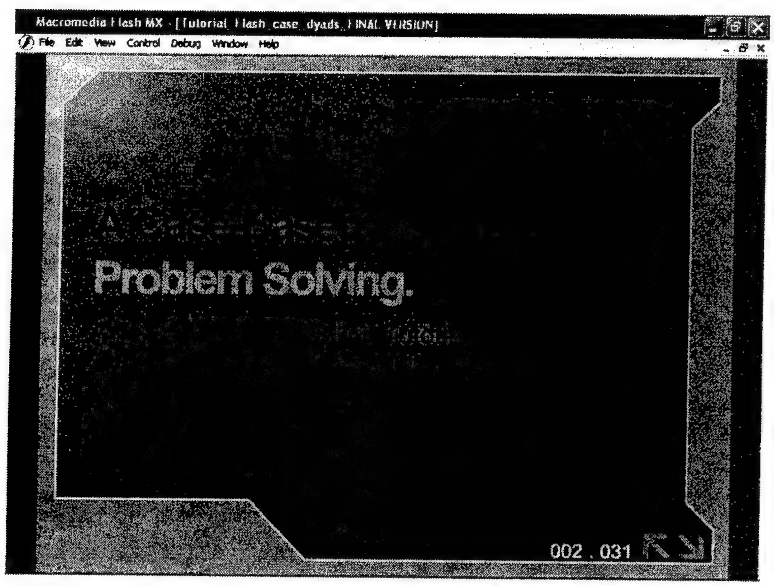
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Problem Solving.
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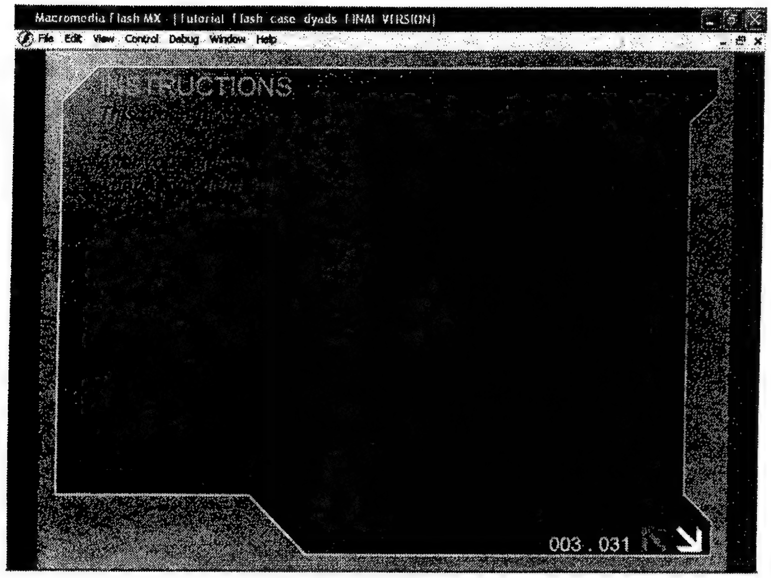
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INSTRUCTIONS
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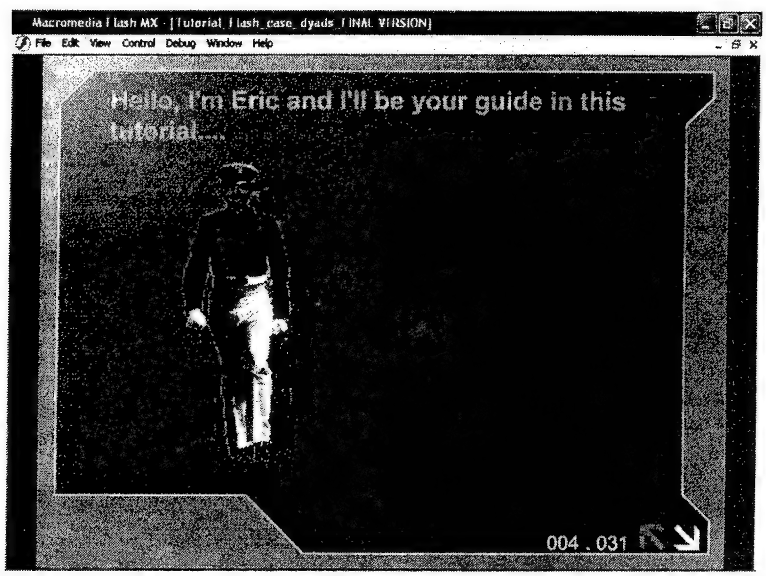
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Hello, I'm Eric and I'll be your guide in this tutorial....
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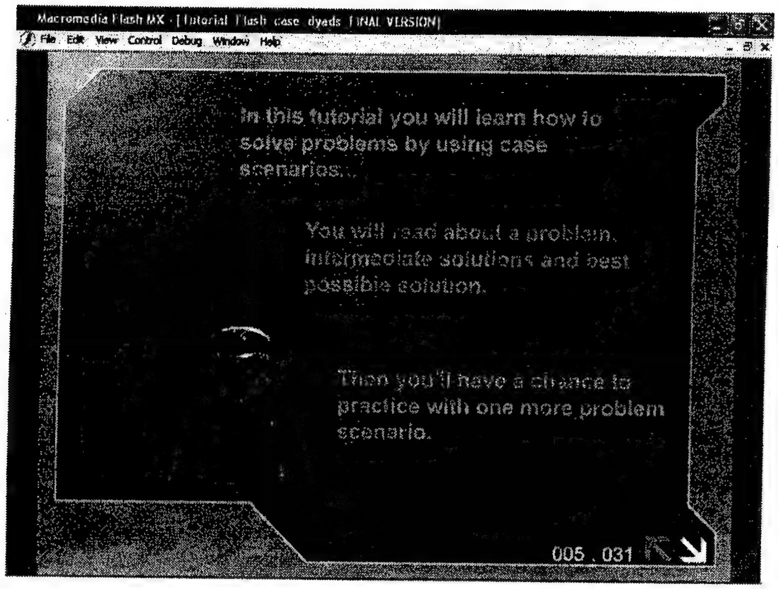
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In this tutorial you will learn how to solve problems by using case scenarios...
You will read about a problem, intermediate solutions and best possible solution.
Then you'll have a chance to practice with one more problem scenario.
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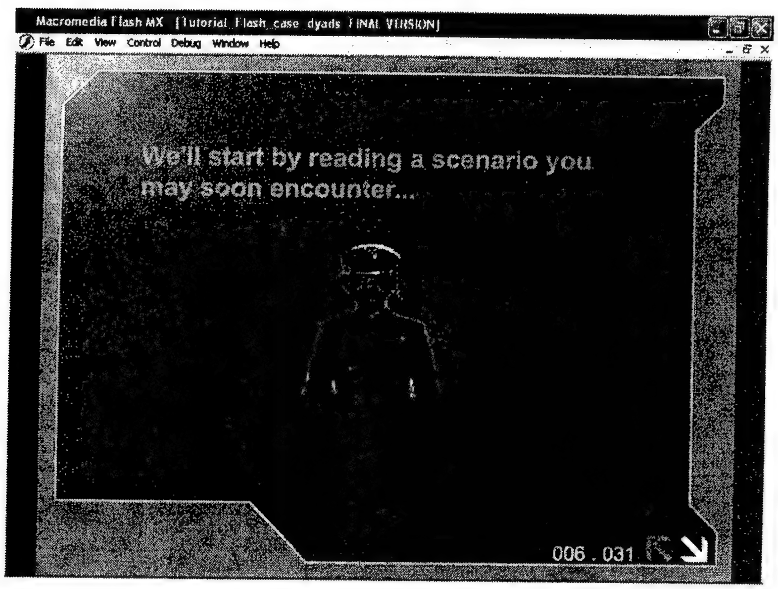
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We'll start by reading a scenario you may soon encounter...
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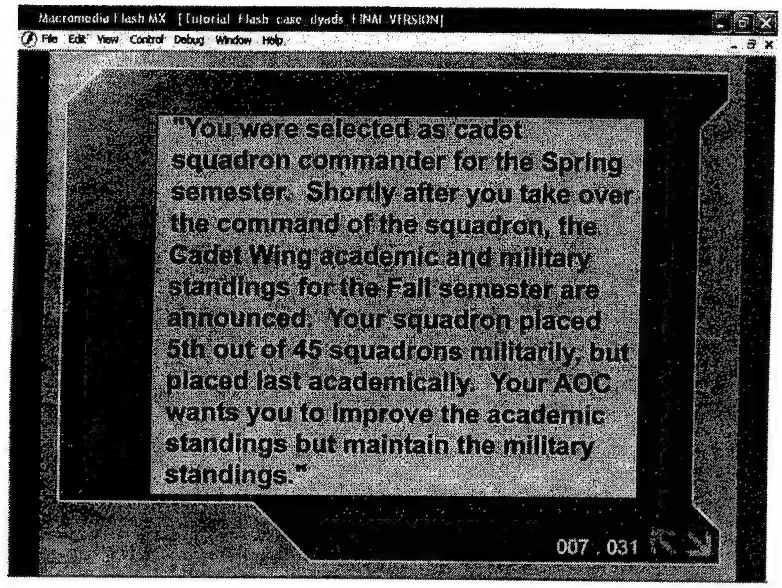
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"You were selected as cadet squadron commander for the Spring semester. Shortly after you take over the command of the squadron, the Cadet Wing academic and military standings for the Fall semester are announced. Your squadron placed 5th out of 45 squadrons militarily, but placed last academically. Your AOC wants you to improve the academic standings but maintain the military standings."
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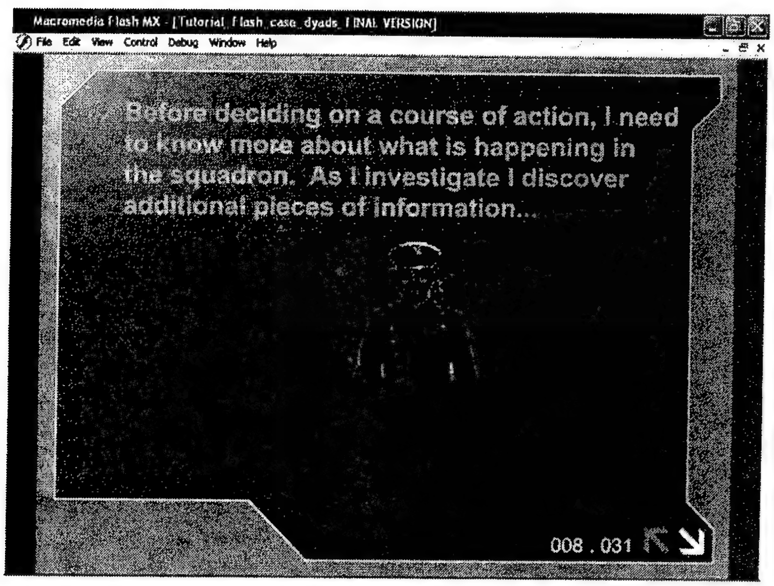
Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
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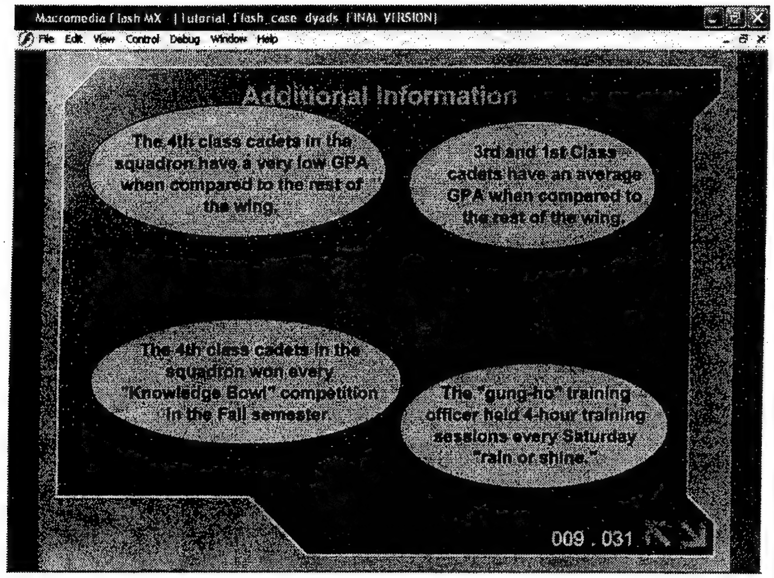
Before deciding on a course of action, I need to know more about what is happening in the squadron. As I investigate I discover additional pieces of information...
008 . 031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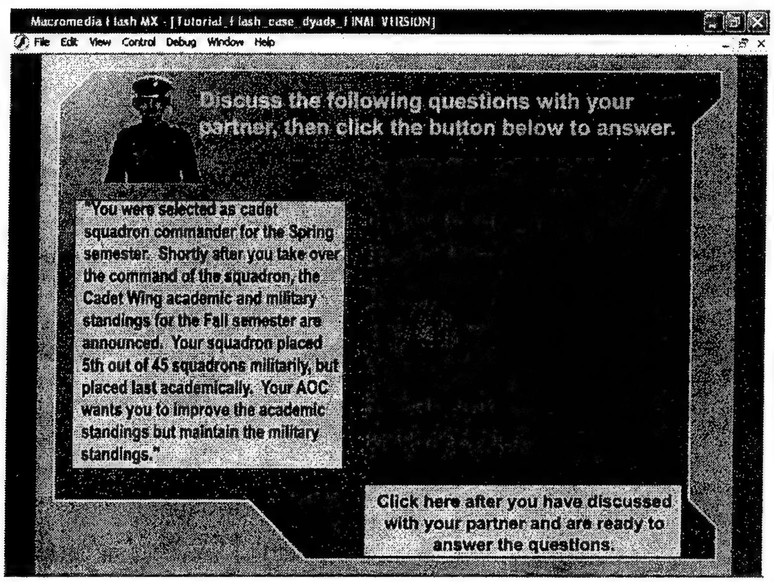
Additional Information
The 4th class cadets in the squadron have a very low GPA when compared to the rest of the wing.
3rd and 1st Class cadets have an average GPA when compared to the rest of the wing.
The 4th class cadets in the squadron won every "Knowledge Bowl" competition in the Fall semester.
The "gung-ho" training officer held 4-hour training sessions every Saturday "rain or shine."
009 . 031


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
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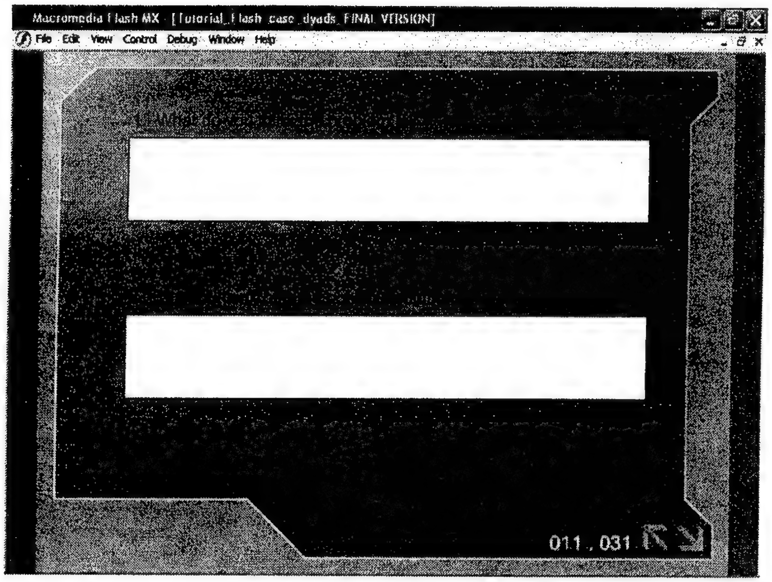
Discuss the following questions with your partner, then click the button below to answer.
"You were selected as cadet squadron commander for the Spring semester. Shortly after you take over the command of the squadron, the Cadet Wing academic and military standings for the Fall semester are announced. Your squadron placed 5th out of 45 squadrons militarily, but placed last academically. Your AOC wants you to improve the academic standings but maintain the military standings."
Click here after you have discussed with your partner and are ready to answer the questions.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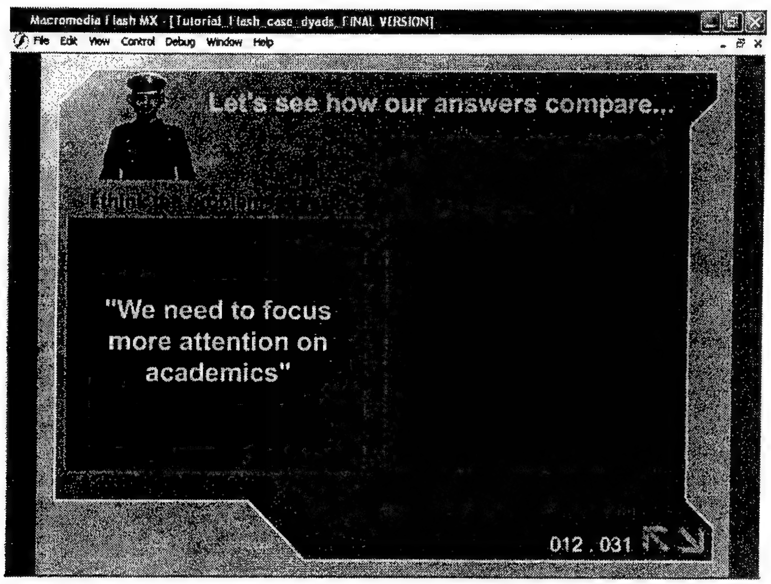
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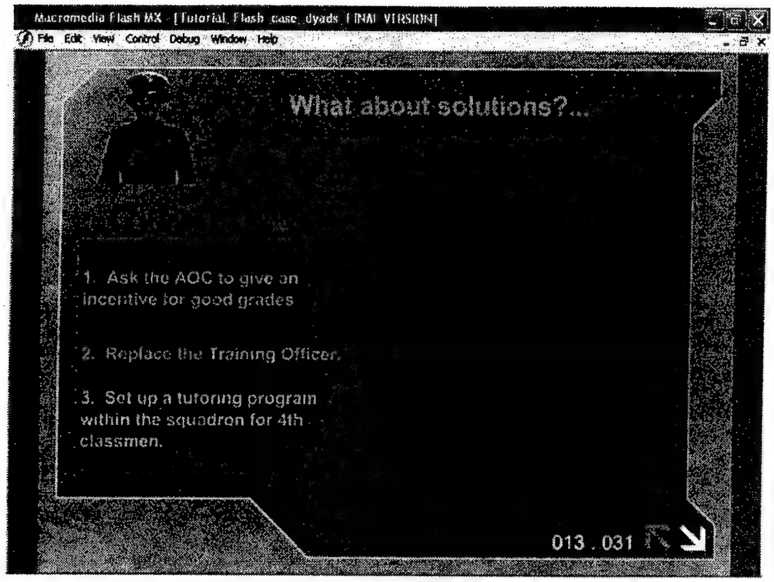
Let's see how our answers compare...
"We need to focus more attention on academics"
012 . 031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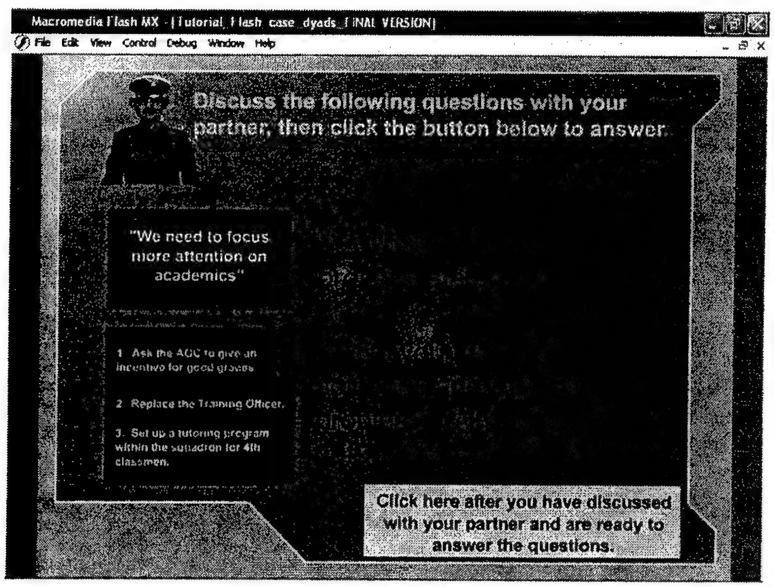
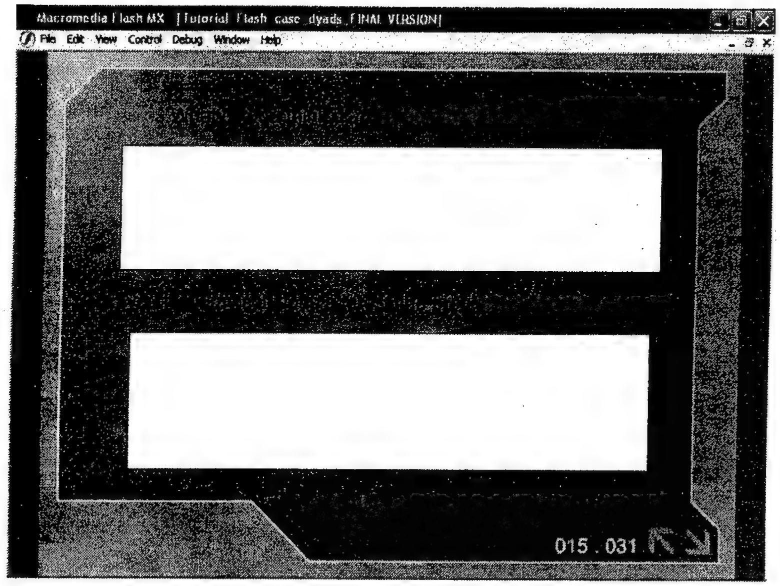
What about solutions?...
1. Ask the AOC to give an incentive for good grades
2. Replace the Training Officer.
3. Set up a tutoring program within the squadron for 4th classmen.
013 . 031


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
File Edit View Control Debug Window Help
Discuss the following questions with your partner, then click the button below to answer.
"We need to focus more attention on academics"
1. Ask the AOC to give an incentive for good grades
2. Replace the Training Officer.
3. Set up a tutoring program within the squadron for 4th classmen.
Click here after you have discussed with your partner and are ready to answer the questions.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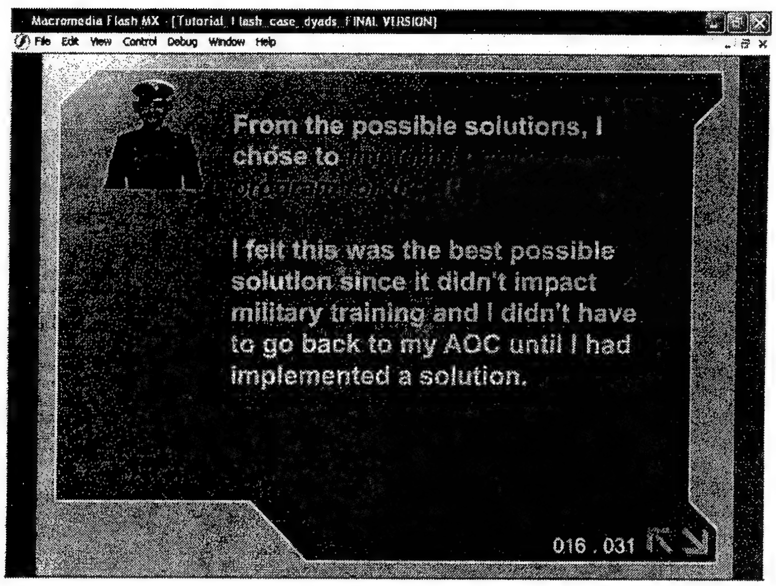
015 . 031


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
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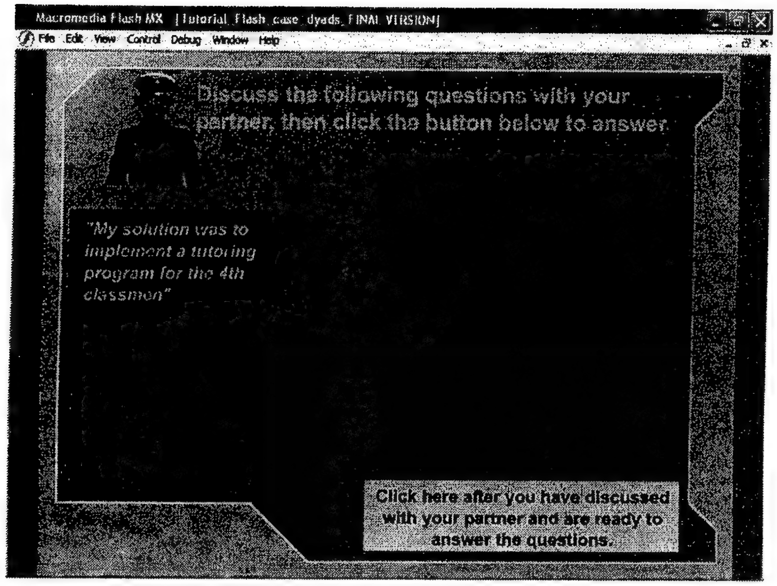
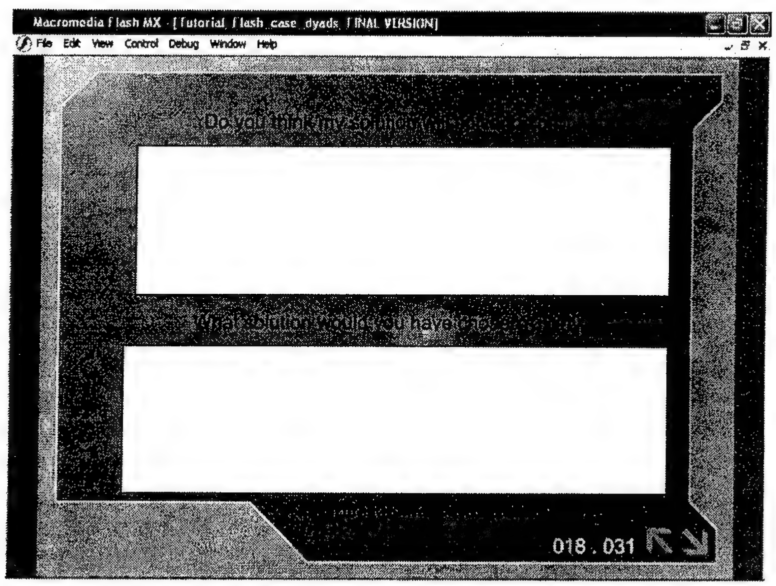
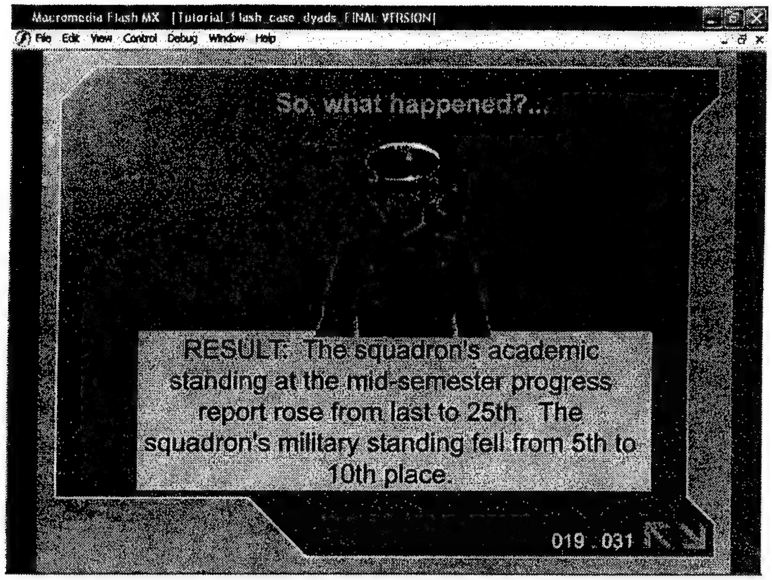
From the possible solutions, I chose to
I felt this was the best possible solution since it didn't impact military training and I didn't have to go back to my AOC until I had implemented a solution.
016 . 031


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
File Edit View Control Debug Window Help
Discuss the following questions with your partner, then click the button below to answer.
"My solution was to implement a tutoring program for the 4th classmen"
Click here after you have discussed with your partner and are ready to answer the questions.


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
File Edit View Control Debug Window Help
Do you think my solution
What solution would you have
018 . 031


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
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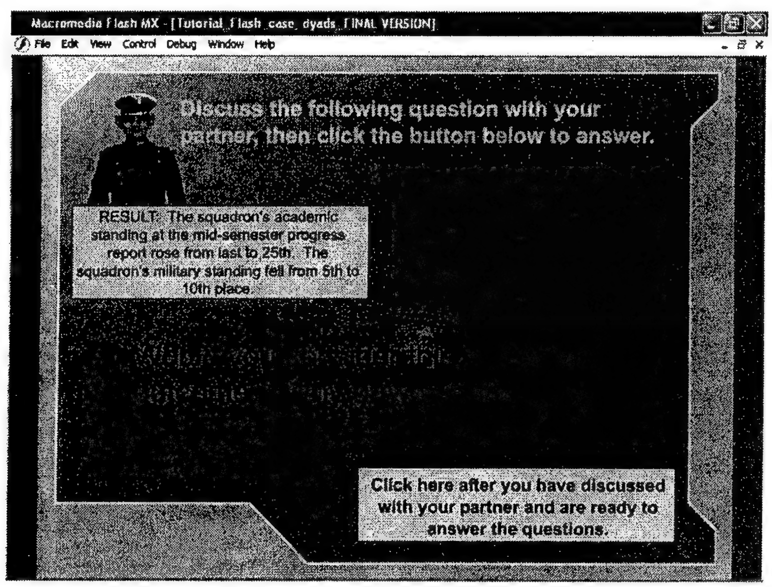
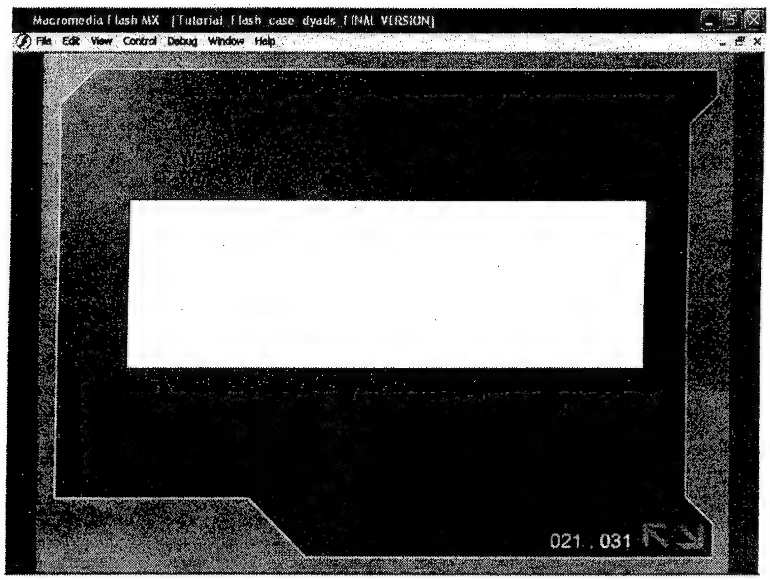
So, what happened?...
RESULT: The squadron's academic standing at the mid-semester progress report rose from last to 25th. The squadron's military standing fell from 5th to 10th place.
019 . 031


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
File Edit View Control Debug Window Help
Discuss the following question with your partner, then click the button below to answer.
RESULT: The squadron's academic standing at the mid-semester progress report rose from last to 25th. The squadron's military standing fell from 5th to 10th place.
Click here after you have discussed with your partner and are ready to answer the questions.


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
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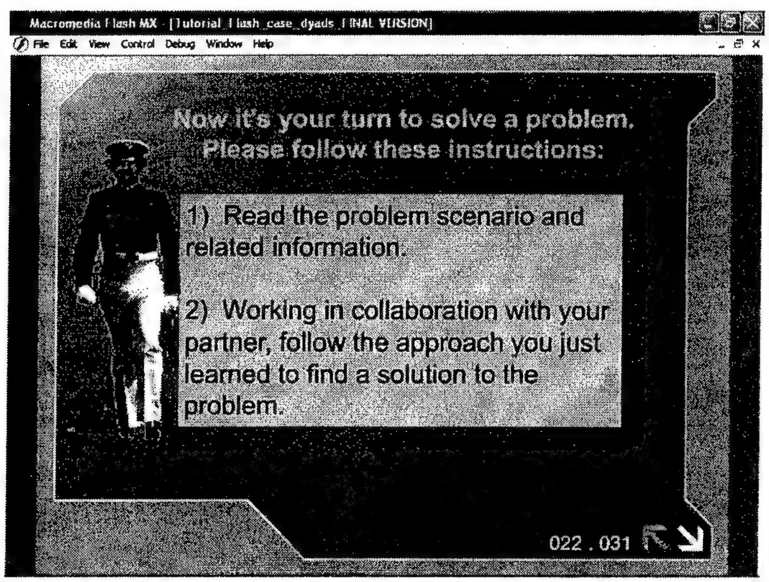
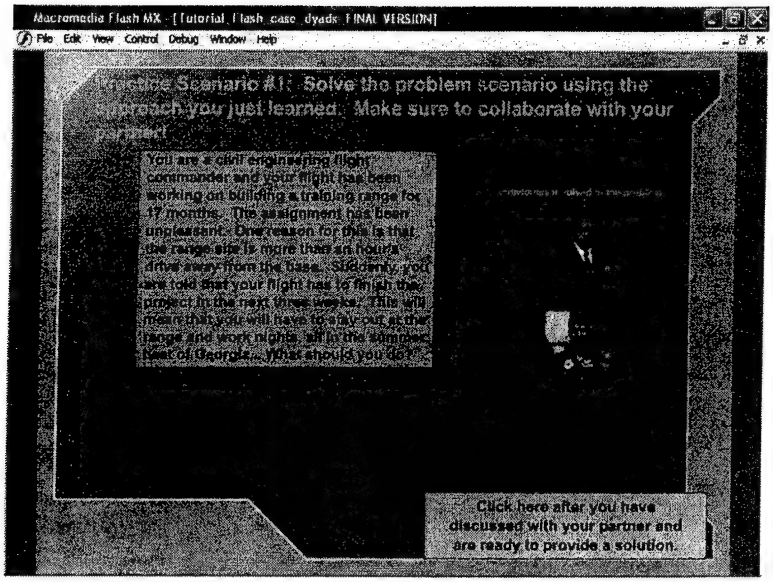
021 . 031


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
File Edit View Control Debug Window Help
Now it's your turn to solve a problem.
Please follow these instructions:
1) Read the problem scenario and related information.
2) Working in collaboration with your partner, follow the approach you just learned to find a solution to the problem.
022 . 031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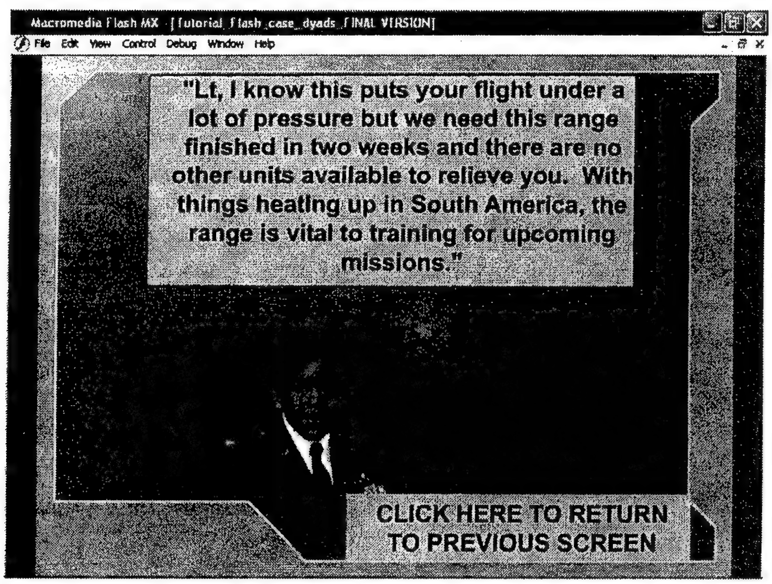
File Edit View Control Debug Window Help
Solve the problem scenario using the
your just learned. Make sure to collaborate with your
commander and your flight has been
17 months. The assignment has been
unpleasant. One reason for this is that
project in the next three weeks. This will
range and work nights, all in the summer
What should you do?
Click here after you have discussed with your partner and are ready to provide a solution.


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
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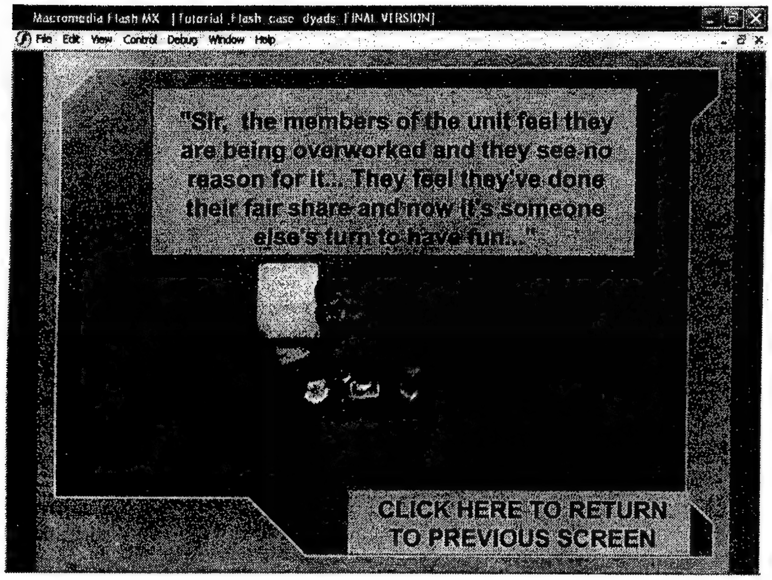
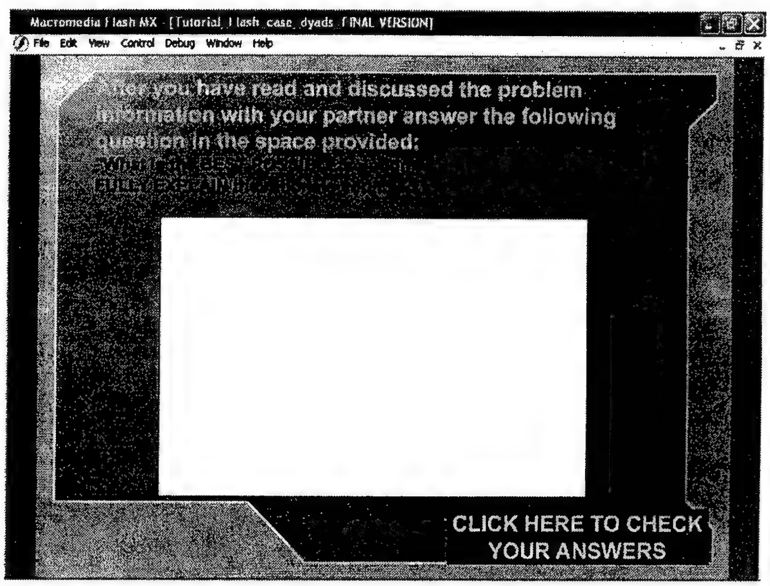
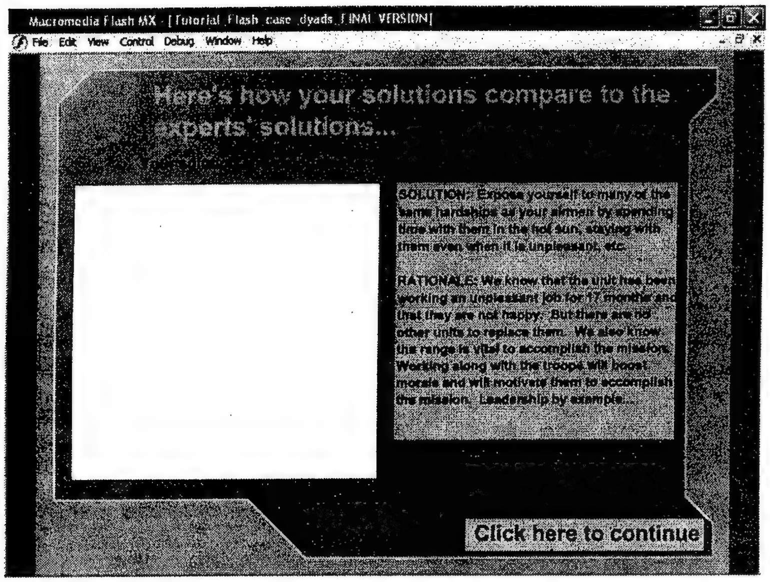
"Lt, I know this puts your flight under a lot of pressure but we need this range finished in two weeks and there are no other units available to relieve you. With things heating up in South America, the range is vital to training for upcoming missions."
CLICK HERE TO RETURN TO PREVIEW SCREEN


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
File Edit View Control Debug Window Help
"Sir, the members of the unit feel they are being overworked and they see no reason for it... They feel they've done their fair share and now it's someone else's turn to have fun..."
CLICK HERE TO RETURN TO PREVIOUS SCREEN


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
File Edit View Control Debug Window Help
you have read and discussed the problem
with your partner answer the following
in the space provided:
CLICK HERE TO CHECK YOUR ANSWERS


Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
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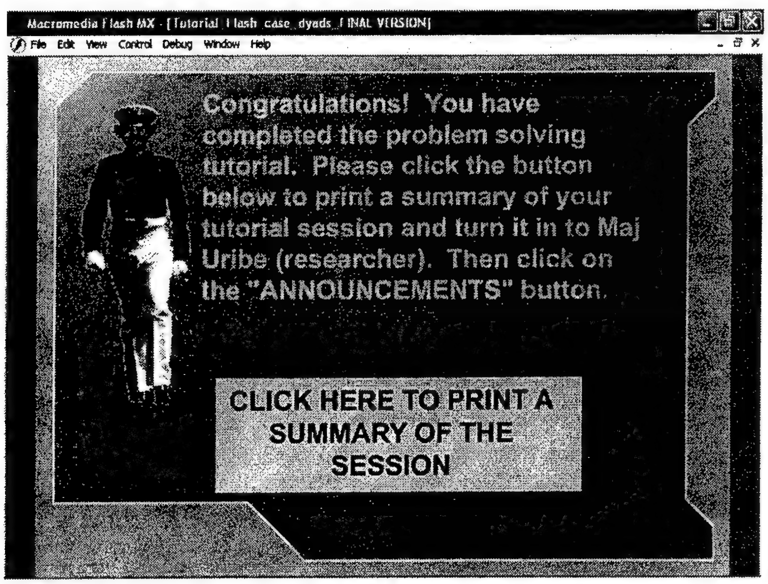
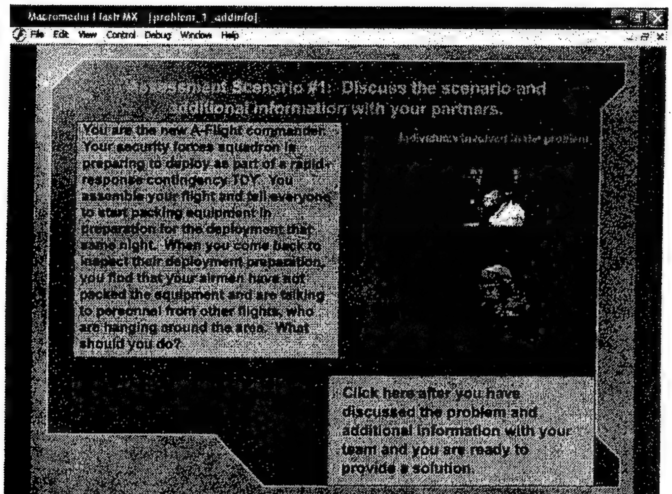
Here's how your solutions compare to the experts' solutions...
SOLUTION: Expose yourself to many of the same hardships as your airmen by spending time with them in the hot sun, staying with them even when it is unpleasant, etc.
RATIONALE: We know that the unit has been working an unpleasant job for 17 months and that they are not happy. But there are no other units to replace them. We also know the range is vital to accomplish the mission. Working along with the troops will boost morale and will motivate them to accomplish the mission. Leadership by example...
Click here to continue

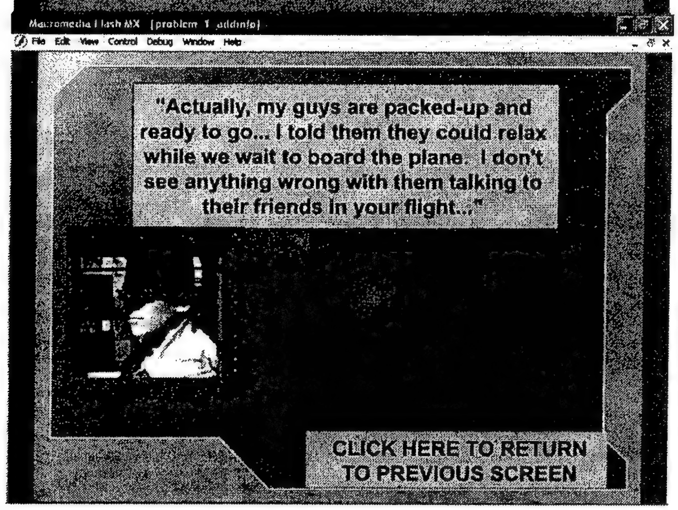

Macromedia Flash MX - [Tutorial_Flash_case_dyads_FINAL VERSION]
File Edit View Control Debug Window Help
Congratulations! You have completed the problem solving tutorial. Please click the button below to print a summary of your tutorial session and turn it in to Maj Uribe (researcher). Then click on the "ANNOUNCEMENTS" button.
CLICK HERE TO PRINT A SUMMARY OF THE SESSION

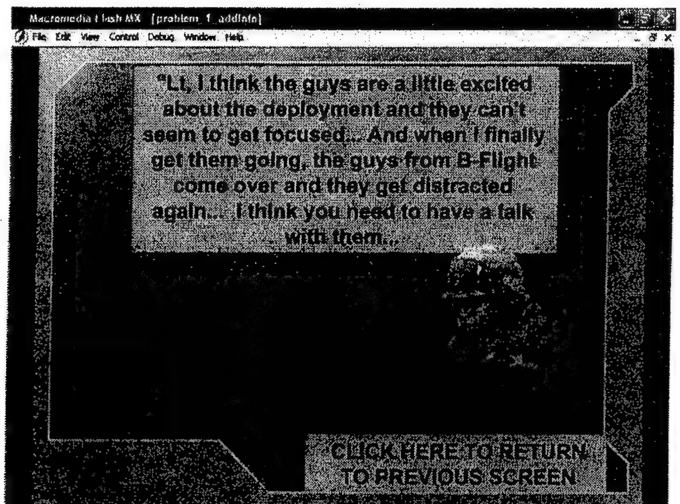
APPENDIX C

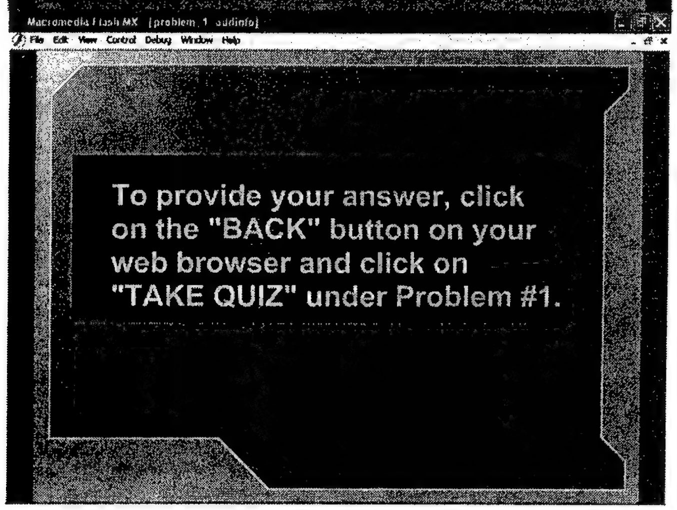
ASSESSMENT SCENARIOS

PROBLEM SCENARIO #1

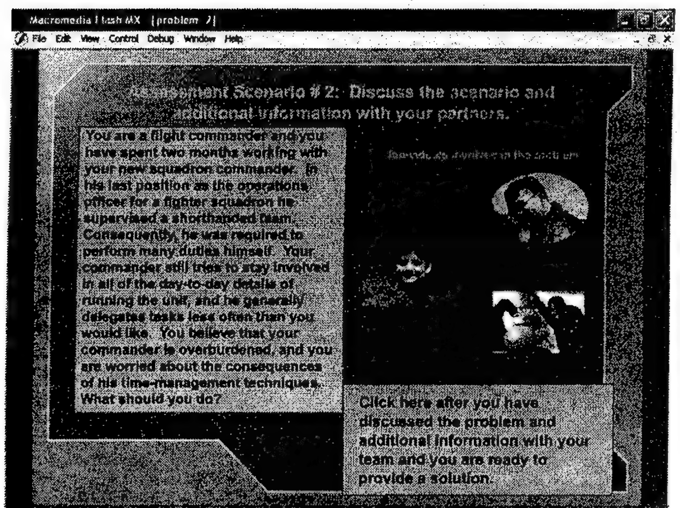


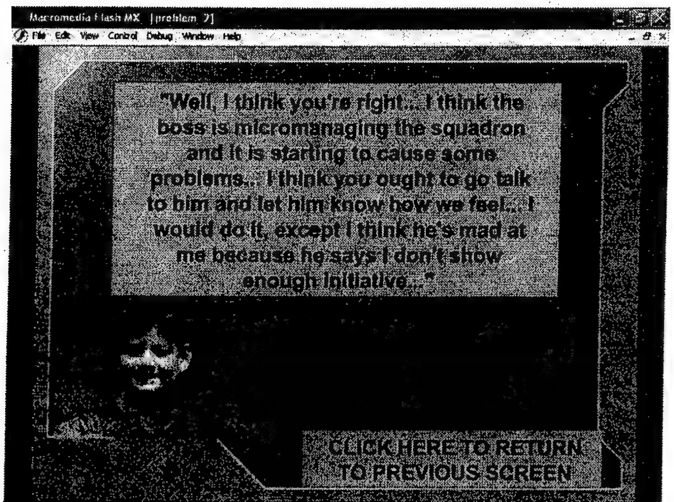


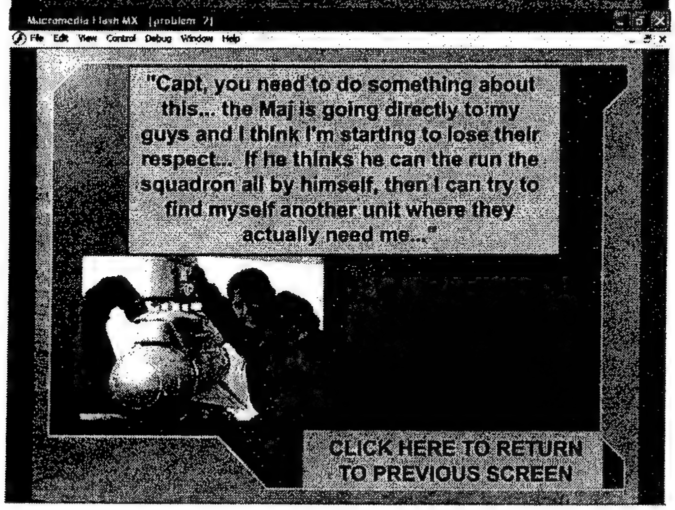

"Lt, I think the guys are a little excited about the deployment and they can't seem to get focused... And when I finally get them going, the guys from B-Flight come over and they get distracted again... I think you need to have a talk with them..."
CLICK HERE TO RETURN TO PREVIOUS SCREEN

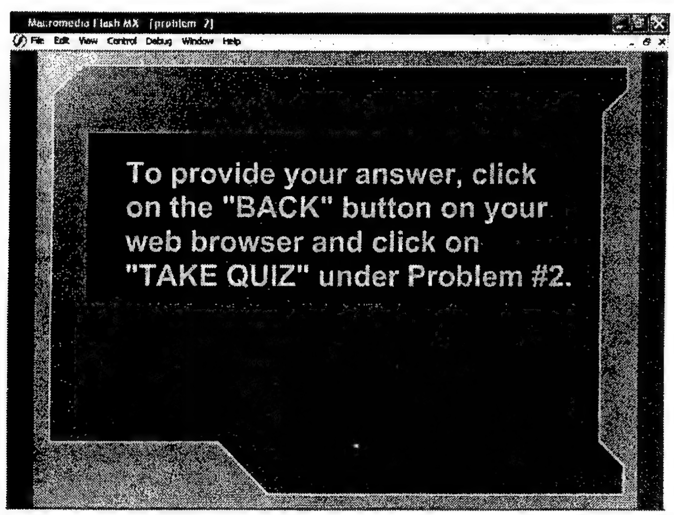

To provide your answer, click on the "BACK" button on your web browser and click on "TAKE QUIZ" under Problem #1.

PROBLEM SCENARIO #2

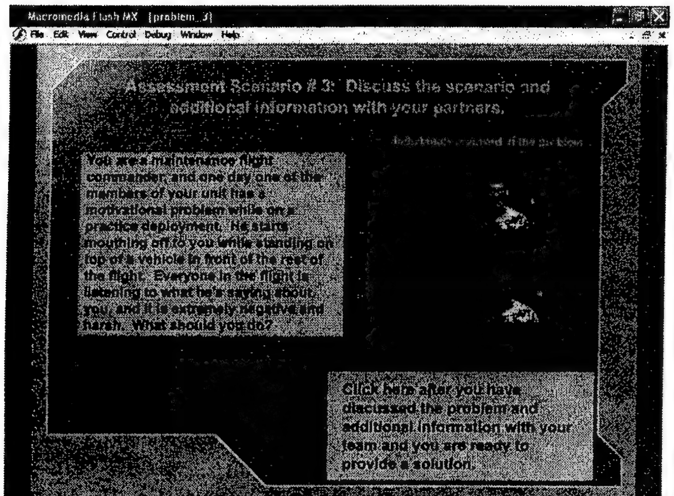


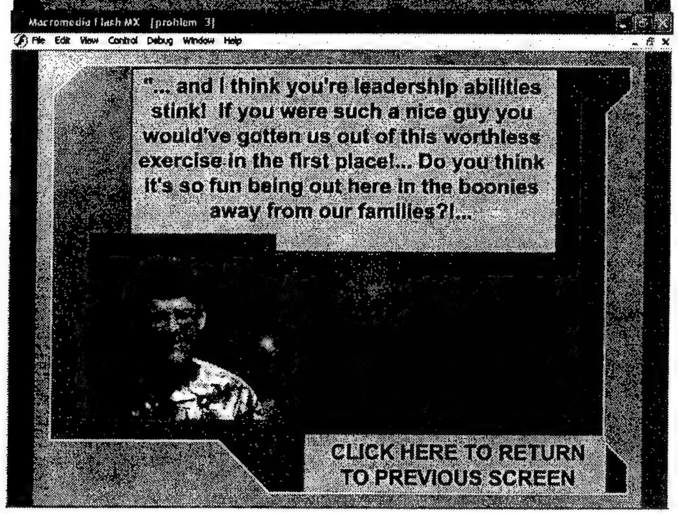

"Well, I think you're right... I think the boss is micromanaging the squadron and it is starting to cause some problems... I think you ought to go talk to him and let him know how we feel... I would do it, except I think he's mad at me because he says I don't show enough initiative..."
CLICK HERE TO RETURN TO PREVIOUS SCREEN

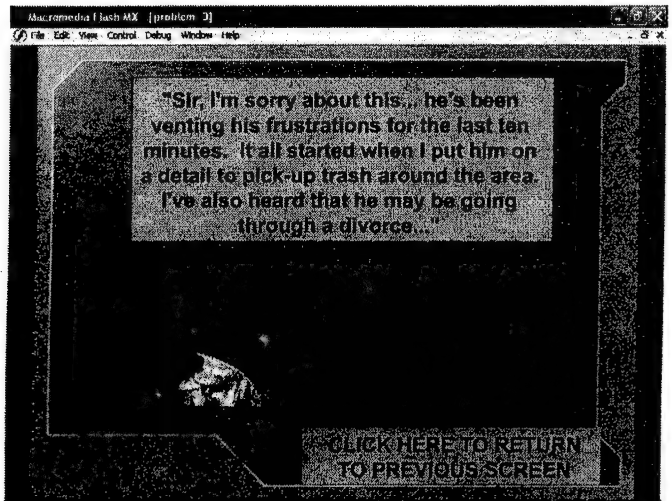

"Capt, you need to do something about this... the Maj is going directly to my guys and I think I'm starting to lose their respect... If he thinks he can the run the squadron all by himself, then I can try to find myself another unit where they actually need me..."
CLICK HERE TO RETURN TO PREVIOUS SCREEN

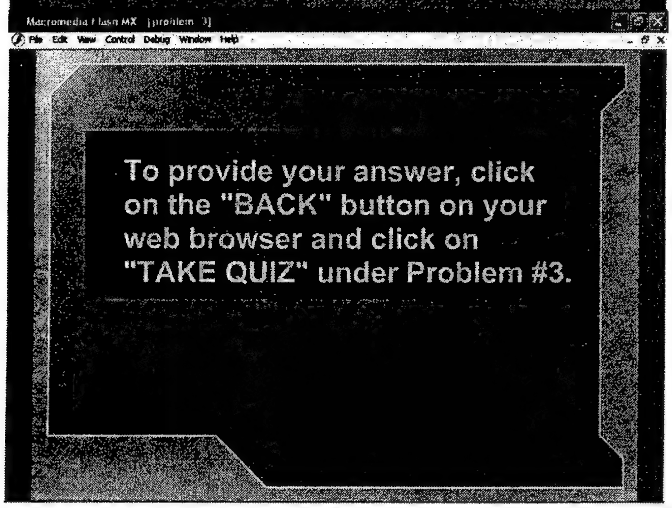

To provide your answer, click on the "BACK" button on your web browser and click on "TAKE QUIZ" under Problem #2.

PROBLEM SCENARIO #3






Macromedia Flash MX [problem 3]
File Edit View Control Debug Window Help
"Sir, I'm sorry about this... he's been venting his frustrations for the last ten minutes. It all started when I put him on a detail to pick-up trash around the area. I've also heard that he may be going through a divorce..."
CLICK HERE TO RETURN TO PREVIOUS SCREEN


Macromedia Flash MX [problem 3]
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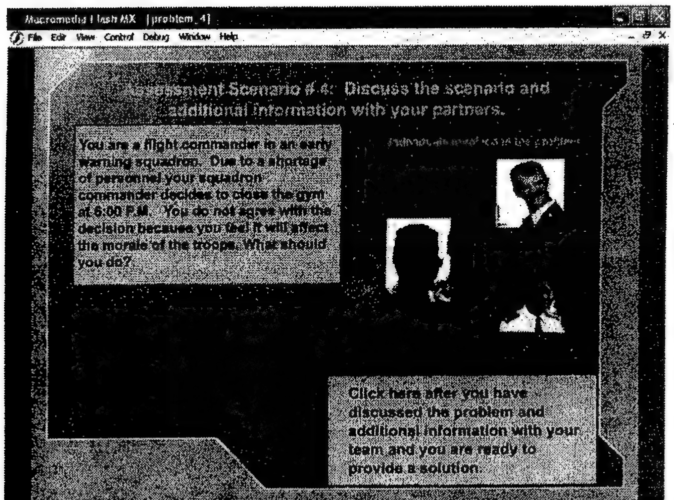
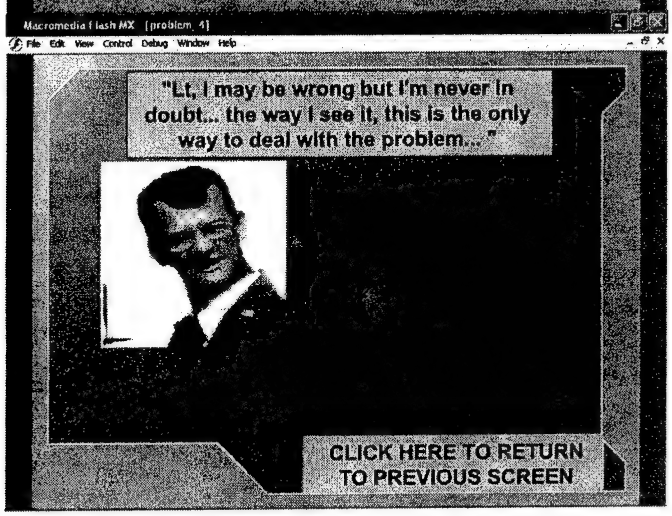
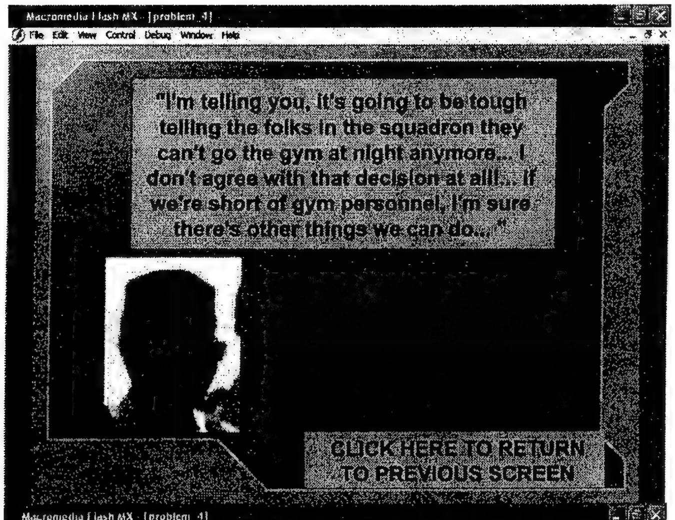
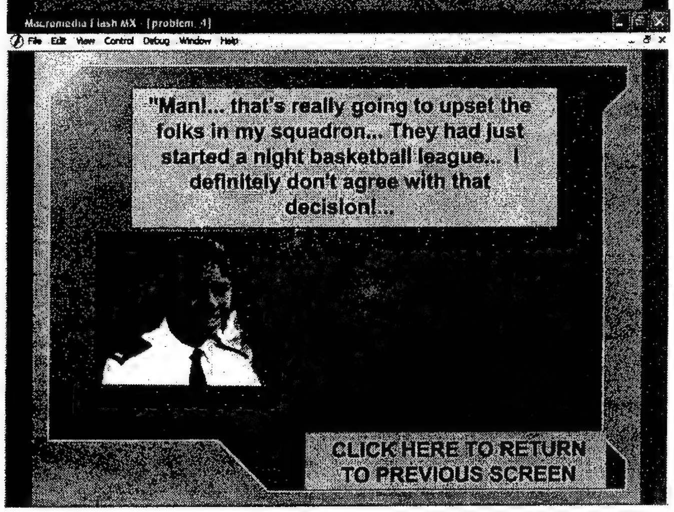
To provide your answer, click on the "BACK" button on your web browser and click on "TAKE QUIZ" under Problem #3.

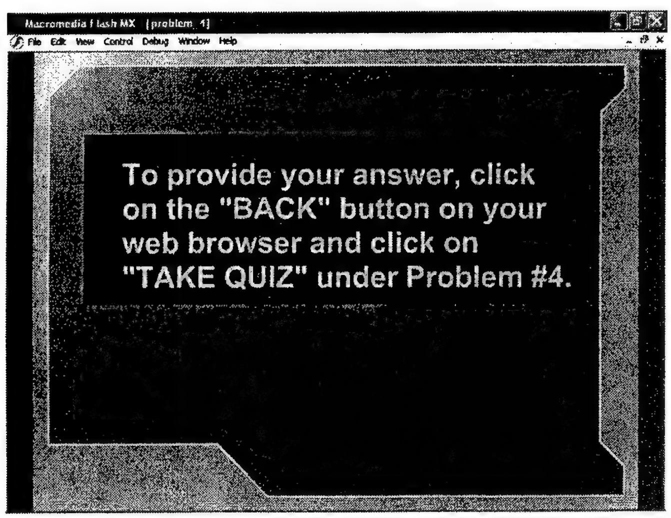
PROBLEM SCENARIO #4






Macromedia Flash MX - [problem_4]
File Edit View Control Debug Window Help
"I'm telling you, it's going to be tough telling the folks in the squadron they can't go the gym at night anymore... I don't agree with that decision at all!... If we're short of gym personnel, I'm sure there's other things we can do..."
CLICK HERE TO RETURN TO PREVIOUS SCREEN


Macromedia Flash MX - [problem_4]
File Edit View Control Debug Window Help
"Man!... that's really going to upset the folks in my squadron... They had just started a night basketball league... I definitely don't agree with that decision!...
CLICK HERE TO RETURN TO PREVIOUS SCREEN


Macromedia Flash MX - [problem_4]
File Edit View Control Debug Window Help
To provide your answer, click on the "BACK" button on your web browser and click on "TAKE QUIZ" under Problem #4.

APPENDIX D

SCORING RUBRIC

ID#______________________ TOTAL SCORE_________/18

Problem # 1	0	1	2
Current State or Problem Definition	Answer is blank or it does not demonstrate an understanding of the problem.	Answer demonstrates a basic understanding of the symptoms of the problem but the root cause is not addressed.	The answer shows a clear understanding of the root cause of the problem.
End State or Goal	Answer is blank or the goal is inconsistent with the problem scenario.	The end-state shown by the answer is related to the problem scenario, but achieving the goal will not solve the problem.	The end state is clear and directly addresses the current state or problem. Reaching the goal solves the problem.
Process	Answer is blank or not enough supporting information is provided to justify the answer.	Enough supporting evidence is provided to justify the problem solution.	The rationale provided demonstrates a logical path and fully supports the solution.
Recommended Solution	Answer is blank or the solution does not address the problem.	Recommended solution addresses the problem but is not optimal. For example: "Assemble your entire flight and tell them that their work priorities are not on target."	Recommended solution is the optimal solution for the problem scenario. For example: "Take charge of the situation, get your unit moving, then talk to them to prevent the problem from happening again."
Problem #2	**0**	**1**	**2**
Current State or Problem Definition	Answer is blank or it does not demonstrate an understanding of the problem.	Answer demonstrates a basic understanding of the symptoms of the problem but the root cause is not addressed.	The answer shows a clear understanding of the root cause of the problem.
End State or Goal	Answer is blank or the goal is inconsistent with the problem scenario.	The end-state shown by the answer is related to the problem scenario, but achieving the goal will not solve the problem.	The end state is clear and directly addresses the current state or problem. Reaching the goal solves the problem.
Process	Answer is blank or not enough supporting information is provided to justify the solution.	Enough supporting evidence is provided to justify the problem solution.	The rationale provided demonstrates a logical path and fully supports the solution.
Recommended Solution	Answer is blank or the solution does not address the problem.	Recommended solution addresses the problem but is not optimal. For example: "Assume this is just the way he is and do your best to get along."	Recommended solution is the optimal solution for the problem scenario. For example: "Offer to take care of specific tasks before he mentions them to you."

Problem #3	**0**	**1/8**	**1/4**
Current State or Problem Definition	Answer is blank or it does not demonstrate an understanding of the problem.	Answer demonstrates a basic understanding of the symptoms of the problem but the root cause is not addressed.	The answer shows a clear understanding of the root cause of the problem.
End State or Goal	Answer is blank or the goal is inconsistent with the problem scenario.	The end-state shown by the answer is related to the problem scenario, but achieving the goal will not solve the problem.	The end state is clear and directly addresses the current state or problem. Reaching the goal solves the problem.
Process	Answer is blank or not enough supporting information is provided to justify the answer.	Enough supporting evidence is provided to justify the problem solution.	The rationale provided demonstrates a logical path and fully supports the solution.
Recommended Solution	Answer is blank or the solution does not address the problem.	Recommended solution addresses the problem but is not optimal. For example: "Do nothing; walk away and wait for him to blow off steam."	Recommended solution is the optimal solution for the problem scenario. For example: "Pull him aside, talk to him in private, and try to find out what's wrong."
Problem #4	**0**	**1/8**	**1/4**
Current State or Problem Definition	Answer is blank or it does not demonstrate an understanding of the problem.	Answer demonstrates a basic understanding of the symptoms of the problem but the root cause is not addressed.	The answer shows a clear understanding of the root cause of the problem.
End State or Goal	Answer is blank or the goal is inconsistent with the problem scenario.	The end-state shown by the answer is related to the problem scenario, but achieving the goal will not solve the problem.	The end state is clear and directly addresses the current state or problem. Reaching the goal solves the problem.
Process	Answer is blank or not enough supporting information is provided to justify the answer.	Enough supporting evidence is provided to justify the problem solution.	The rationale provided demonstrates a logical path and fully supports the solution.
Recommended Solution	Answer is blank or the solution does not address the problem.	Recommended solution addresses the problem but is not optimal. For example: "Go back to the squadron commander and tell him/her that because you do not agree with the decision, it will be very hard for you to gain the support of the NCOs and troops to carry out the battery commander's wishes. "	Recommended solution is the optimal solution for the problem scenario. For example: "Wait an hour after the meeting, then approach the battery commander with an alternative solution."

APPENDIX E

PARTICIPANT SURVEY

PARTICIPANT SURVEY

We are conducting this survey to get your perceptions about the Problem Solving program you just completed. Your honest feedback will help us determine areas for improvement. Please rate statements 1-18 below using the following rating scale:

SD - Strongly Disagree **D** - Disagree **A** – Agree **SA** - Strongly Agree

1. I enjoyed working with other people on the program.	**SD**	**D**	**A**	**SA**
2. The program was easier to do because I worked with other people.	**SD**	**D**	**A**	**SA**
3. Working with others helped me do better on the program.	**SD**	**D**	**A**	**SA**
4. I liked communicating with my team using the computer.	**SD**	**D**	**A**	**SA**
5. Collaborating with my team using the computer was easy to do.	**SD**	**D**	**A**	**SA**
6. Collaborating with my team using the computer was just as effective as if I was talking to them face-to-face.	**SD**	**D**	**A**	**SA**
7. I learned a lot from the tutorial.	**SD**	**D**	**A**	**SA**
8. The tutorial prepared me well to solve the problem scenarios.	**SD**	**D**	**A**	**SA**
9. My team and I used the information we learned on the tutorial to solve the assessment scenarios.	**SD**	**D**	**A**	**SA**
10. Overall, the tutorial was a high-quality product.	**SD**	**D**	**A**	**SA**
11. I liked having an "animated" cartoon teach the tutorial.	**SD**	**D**	**A**	**SA**
12. The tutorial's graphics and animations helped me to understand difficult concepts.	**SD**	**D**	**A**	**SA**
13. The time allotted for the tutorial was just about right.	**SD**	**D**	**A**	**SA**
14. My team and I had enough time to solve all the problem scenarios.	**SD**	**D**	**A**	**SA**
15. The time allotted for the entire program (tutorial and assessment) was just about right.	**SD**	**D**	**A**	**SA**
16. The scenarios in this program were realistic and applicable to a future Air Force officer.	**SD**	**D**	**A**	**SA**
17. I feel better prepared to solve everyday problems after doing this program.	**SD**	**D**	**A**	**SA**
18. The problem solving skills I learned in this program will help me in my Air Force career.	**SD**	**D**	**A**	**SA**

ADDITIONAL COMMENTS ON NEXT PAGE

19. When solving complex problems, I prefer to work:

    a. By myself.
    b. With one partner.
    c. With two partners.
    d. With more than two partners.

20. Please write down the general steps that you followed to solve the assessment problem scenarios.

21. What did you like **best** about the Problem Solving program?

22. What would you do to make this program better?

APPENDIX F

PRE-TREATMENT INSTRUMENT

PROBLEM SCENARIO

"You are the captain of your high school soccer team and you have noticed that the younger members of the squad are being disrespectful to the coach behind her back. This attitude is starting to affect the discipline of the team and the performance on the field..."

In the space below, briefly explain the <u>PROCESS</u> you would follow to solve the problem. (NOTE: Do not provide a solution; just describe the process you would use.)

APPENDIX G

RECRUITMENT SCRIPT

CLASSROOM RECRUITMENT SCRIPT

"GOOD MORNING (AFTERNOON). MY NAME IS DANIEL URIBE AND I AM CURRENTLY A STUDENT AT ARIZONA STATE UNIVERSITY PURSUING A PHD IN EDUCATIONAL TECHNOLOGY. THE PURPOSE OF MY VISIT TODAY IS TO ASK FOR VOLUNTEERS TO PARTICIPATE IN A STUDY THAT I WILL BE CONDUCTING OVER THE NEXT TWO LESSONS. THE PURPOSE OF THE STUDY IS TO INVESTIGATE THE EFFECTIVENESS OF TWO DIFFERENT TEACHING METHODS ON THE ABILITY OF STUDENTS TO RESOLVE ILL-DEFINED PROBLEMS IN A WEB-BASED ENVIRONMENT.

THE STUDY WILL TAKE PLACE DURING TWO CLASS PERIODS AND WILL REQUIRE THAT YOU GO TO THE LANGUAGE LEARNING CENTER (LCC) TWICE. AT THE LCC YOU WILL FIRST WORK THROUGH AN ON-LINE TUTORIAL ON PROBLEM SOLVING. AFTER THE TUTORIAL YOU AND YOUR TEAMMATES WILL BE GIVEN SEVERAL PROBLEM SCENARIOS TO SOLVE WHILE COMMUNICATING ONLINE. AT THE END OF THE STUDY, YOU WILL ALSO BE COMPLETING A SHORT SURVEY ABOUT THE PROGRAM.

IT IS IMPORTANT FOR YOU TO UNDERSTAND THAT PARTICIPATION IN THIS STUDY IS STRICTLY VOLUNTARY. YOU WILL NOT BE PENALIZED IN ANY WAY FOR NOT PARTICIPATING AND YOU CAN CHOOSE TO CEASE YOUR PARTICIPATION AT ANY TIME WITHOUT RETRIBUTION. IF YOU DECIDE TO PARTICIPATE THE TOP TEAM IN EACH GROUP AND THE TOP INDIVIDUAL SCORER WILL BE TREATED TO DINNER AT A POPULAR LOCAL DINING ESTABLISHMENT. ARE THERE ANY QUESTIONS?

I WILL NOW DISTRIBUTE THE INFORMED CONSENT FORMS AND THE PARTICIPANT'S BILL OF RIGHTS. PLASE READ THE BILL OF RIGHTS AND THE INFORMED CONSENT FORM CAREFULLY. IF

YOU AGREE TO PARTICIPATE IN THIS STUDY PLEASE SIGN THE INFORMED CONSENT FORM AND PASS IT FORWARD."

[PAUSE WHILE THE CADETS READ THE FORMS AND SIGN THE ICD]

"THOSE OF YOU WHO AGREED TO PARTICIPATE WILL RECEIVE A COPY OF THE INFORMED CONSENT FORM WITH ALL OF THE APPROPRIATE SIGNATURES PRIOR TO THE START OF THE STUDY. THANK YOU FOR YOUR TIME THIS MORNING (AFTERNOON) AND HAVE A GOOD DAY."

APPENDIX H

SUBJECT'S BILL OF RIGHTS

Research Subject's Bill of Rights[1]

The USAFA Institutional Review Board believes that personal concern for each subject's welfare is indispensable to the quest for knowledge. The most important person in medical or behavioral research is the subject. The research subject is the essential element without whom health, disease or behavior could not be observed and response to treatment or situations could not be measured.

The obligation to protect human subjects applies to research conducted using Department Of Defense (DOD) facilities or property, supported with DOD funds, or performed by DOD employees or contractors. If you are asked to be a research participant, you should know the requirements for protecting your rights to information, privacy and well-being. The rights below are the rights of every person who is asked to be in a research study.

The right to

1. considerate and respectful treatment as a research subject and information on who to contact if I think I am not being treated appropriately.

2. know, by name, the researcher/care provider responsible for coordinating my activities/care.

3. be told how and why I was chosen for the study.

4. be told what the study is trying to find out.

5. be told what will happen to me and whether any of the procedures, drugs, or devices is different from what would be used in standard practice.

6. be told about the frequent and/or important risks, side effects, inconveniences, or discomforts resulting from the things that will happen to me for research purposes.

7. be told of other choices I have and how they may be better or worse than being in the study.

8. be told if I can expect any benefit from participating, and, if so, what the benefit might be.

9. be allowed to ask any questions before agreeing to be involved and then during the course of the study.

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[1] This bill of rights has been adapted from similar documents developed by the American Hospital Association, the University of California at San Francisco and the Office of Energy Research.

10. refuse to participate at all or to change my mind about participation after the study is started and to be told who to contact to terminate my participation. This decision will not affect my right to receive the care I would receive if I were not in the study.

11. be free of pressure when considering whether I wish to agree to be in the study or where to get help if I think I am being pressured to participate in a study.

12. be told what sort of medical treatment is available if any complications arise.

13. expect that all communications and records pertaining to this research will be treated as confidential to the extent permitted by law.

14. know in advance how much time commitment is necessary for involvement in research.

15. receive a copy of the signed and dated consent form.

If I have other questions I should ask the researcher. In addition, I may contact the USAFA Institutional Review Board (IRB), which is concerned with protection of volunteers in research projects, at (719) 333-2587.

APPENDIX I

INFORMED CONSENT DOCUMENT

INFORMED CONSENT DOCUMENT

DEPARTMENT OF THE AIR FORCE
Department of Foreign Languages
USAF ACADEMY, COLORADO, 80840

Privacy Act and Freedom of Information Act

I understand that records of my participation in this study may only be released in accordance with federal law. The Freedom of Information Act, 5 U.S.C. 552, the Federal Privacy Act, 5 U.S.C. 552a, and their implementing regulations may apply.

TITLE OF STUDY

The effect of instructional method and computer-mediated collaboration on performance resolving ill-defined problems.

PROTOCOL NUMBER FAC2002013 DATE STUDY APPROVED 28 June 02 DATE ICD APPROVE 28 June 02

INVESTIGATORS' NAME(S), DEPARTMENT(S), PHONE NUMBER(S)

Lt Col Richard Sutherland, DFF, x3820

Maj Dan Uribe, PhD Candidate, Arizona State University, (480) 759-4786

PURPOSE OF STUDY

I understand that I am being asked to participate in a research study. The purpose of the study is to determine if teaching students how to solve problems systematically (i.e. step-by-step) is any better than teaching students how to solve problems through the use of case studies. There will be approximately 200 cadets participating in the study, which will take place over two 50-minute class periods.

PROCEDURES

Approximately 1 week prior to the study, I will receive instructions on how to log-in to the Blackboard system. At that time I will also receive general instructions on where to go on the day of the study. On the day of the study, I will be directed to a workstation in the Language Learning Center and will follow the instructions that will be displayed on the screen. At the end of the computer-mediated program, I will complete an attitude survey to collect information about my attitudes toward the instructional program, working in groups and transfer of the information learned. My personal information will be stored in the DFF server and will be password protected. This personal information will only be accessed by the primary and associate researchers. Any identifiable information will be destroyed once the data analysis is complete.

BENEFITS

I understand there are direct benefits from my participation in this study. If I am a member of one of the top teams or if I am the top individual scorer, I understand I will be treated to dinner at a popular local dining establishment.

I understand that an alternative to participation in this research is to not participate.

RISKS/INCONVENIENCES

I understand there are no risks associated with this study. I also understand that the only inconvenience for participating in this study will be the two trips I will have to make to the Language Learning Center.

COMPENSATION FOR TREATMENT OF INJURY

I understand that my entitlement to medical and dental care and/or compensation in the event of injury is governed by federal laws and regulations. If I have questions about my rights or if I believe I have received a research-related injury, I may contact the USAF Academy Institutional Research and Assessment Division (HQ USAFA/XPR) at 719-333-2587.

DECISION TO PARTICIPATE

The decision to participate in this study is completely voluntary on my part. No one has coerced or intimidated me into participating in this program. My alternative to participating in this study is to choose not to participate. I understand that if I refuse to participate, I will not lose any benefits that I am entitled to. I also understand that a non-graded activity will be available for me as an alternative to participation in this study. I am participating because I want to. My investigator has adequately answered any and all questions I have about this study, my participation, and the procedures involved. I understand that an investigator will be available to answer any questions concerning procedures throughout this study. I understand that if significant new findings develop during the course of this study that may relate to my decision to continue participation, I will be informed. I further understand that I may withdraw this consent at any time and discontinue further participation in this study without prejudice to my rights. I also understand that the investigator may terminate my participation in this study at any time if he/she feels this to be in my best interest. I have been provided a copy of this consent form.

QUESTIONS REGARDING MY PARTICIPATION IN THIS RESEARCH STUDY

If I have questions about this research study, I should contact the principal investigator, Lt Col Richard Sutherland, at x3820. If I have questions about my rights as a research *participant*, or if I have received a research-related injury, I should contact the USAF Academy Institutional Research and Assessment Division
(HQ USAFA/XPR) at 719-333-2587.

My signature below indicates my willingness to participate in this research study, my receipt of a copy of this document, with all three required signatures, and a copy of the Research Subject's Bill of Rights.

____________________ ______________

Participant's printed name Participant's SSAN

____________________ ______________

Participant's signature Date

______________________________ ____________

Advising Investigator's Signature Advising Investigator's SSAN Date

I witnessed the participant's signature to this informed consent document.

______________________________ ____________

Witness' Signature Witness's SSAN Date

Distribution: Principal Investigator and Participant.